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Transit Garage Planning Guidelines

A Review

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Transit Garage Planning Guidelines

A Review

Final Report
August 1987

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FOREWORD

The planning of a bus maintenance facility is an important event in most transit systems. The decisions that are made about the location, size, and design of a maintenance facility will affect the performance of the transit system for many years into the future. Therefore, great care must be taken in the planning of these facilities.

The Office of Planning Assistance in the Urban Mass Transportation Administration has initiated a study on the planning of bus maintenance facilities. The objective of the study is to produce a manual that enable transit systems to plan maintenance facilities in a logical, comprehensive manner.

This document is the first interim report from the study. It is a summary of a review of 33 bus maintenance facilities that have opened since 1975. The review covered the procedures used to plan the facilities and the space allocated to various functions in the facilities. We believe this "State-of-the-Practice" review will be useful to transit systems in their maintenance planning efforts.

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Mr. Joseph Bartkiewicz -- Greater Cleveland Regional Transit Authority

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The project staff of SG Associates, Inc. who participated were Mr. Frank Spielberg, Mr. Stephen Andrle, Mr. Howell Glasser and Mr. Alan Brick-Turin. Mr. Robert Gibson and Mr. George Shoemaker were the principal participants from Clark, Nexsen, Owen, Barbieri and Gibson.

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I. INTRODUCTION

HISTORICAL BACKGROUND

Following three to four decades in which there was little capital investment in transit facilities, transit systems throughout the nation have been actively involved in construction and rehabilitation of public transit maintenance facilities. The Urban Mass Transportation Act of 1964, as amended, provides for Federal support in acquisition of capital property, including maintenance facilities. In the past twenty years many transit properties have been engaged in constructing or rehabilitating maintenance facilities.

Prior to the 1960's many transit maintenance facilities across the country were being operated beyond their economic life. The Great Depression, the war years, and post-war years when transit ridership declined severely were all periods which were unfavorable to capital investment in transit. As a result very few transit maintenance facilities were built between 1929 and 1965. A forty-year life cycle is typically expected of an industrial building. By the 1960's, the transit industry was by and large operating from facilities built between the 1890's and the 1920's which were obsolete, overcrowded, and uneconomical.

Knowledge of good planning principles for designing facilities was also limited and not widespread. Because of the long hiatus in construction of transit maintenance facilities, some facility design knowledge had been lost. Also, since the shift from streetcars to motor buses occurred during this period, design standards for new bus maintenance facilities were developed from experience gained in facilities adapted from streetcar use. There were few facilities which had been designed for bus use. Finally, each transit system that built a new facility in the 1960's and 1970's developed its own guidelines in association with architect/engineer contractors. A limited

amount of sharing of knowledge occurred, of course, from system to system, but this network did not include all systems. Larger systems tended to be more active, because they built the most new facilities. Smaller properties looked to them for assistance.

In 1975 the Urban Mass Transportation Administration (UMTA) sponsored a research project to document current practice in bus maintenance facility design.[1/] Data from over 100 transit facilities were obtained and the range of then-current design practice displayed. Design measures such as maintenance stalls per bus, fuel islands per 100 buses, and fleet size per facility were calculated for most critical maintenance functions.

While this report was a great contribution to the field, some of the findings are now outdated. Better data are now available on the design of bus facilities. Many obsolete or near obsolete facilities were still in operation at the time of the report. Data from these outmoded facilities were unavoidably mixed with data from newer facilities, resulting in a wide range of values for the design measures used.

New methods have also been developed since the completion of the previous work. For example, new methods for locating transit facilities have been developed. Location is critical, because excessive deadhead time and distance (i.e. time or distance in non-revenue service travelling to and from the garage) and excessive relief costs can occur if a facility is poorly located. A variety of methods have been developed ranging from "good judgment" to complex operations research methods.

A number of issues have also become more important in the past ten years. For example, energy conservation methods have become much more critical.

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1. Bus Maintenance Facilities: A Transit Management Handbook, U. S. Department of Transportation, Urban Mass Transportation Administration, 1975.

Passive solar heating is probably the most dramatic departure from traditional design that has emerged recently. The trend toward indoor storage of buses, caused in part by higher fuel costs which limit overnight idling, is another development of note. The almost universal air conditioning of transit vehicles and the addition of wheel chair lifts to many vehicles generate additional maintenance requirements that must be accommodated in maintenance facilities.

Many new facilities have been built since the 1975 research was conducted. These facilities have incorporated modern design practices and methods and have addressed the "new" issues in facility design. These new facilities and the planning analyses leading to their construction constitute the current state-of-the-practice with respect to bus maintenance facilities.

This report summarizes the state-of-the-practice in bus maintenance facilities planning. Information from thirty-three facilities opened since 1975 was assembled. This information includes the procedures used to plan the facilities and the space allocations for various functions in the facilities. Site specific lessons that may be valuable to others are also included here.

MAINTENANCE FACILITY TYPES

Because the organization structure partially determines what maintenance functions are carried out at particular locations, it is useful to discuss the organization structures commonly found in public transit. There are two basic functional types of transit facilities: (1) the main maintenance garage which acts as the shop where heavy maintenance is carried out, and (2) the operating garages where buses are stored and dispatched. Sometimes, the two basic types are mixed. A single facility in this case would provide an operating base for a resident fleet and main maintenance support for the entire system.

Main Maintenance Facility

A main maintenance facility provides heavy maintenance services for the rest of the transit system. Vehicles are operated out of the main maintenance facility. Functions carried out typically include:

- o Engine overhaul
- o Component rebuilding
- o Major body repairs
- o Painting
- o Upholstery
- o Sign shop
- o Radiator repairs
- o Machine shop
- o Specialty shop
- o Tire shop -- regrooving
- o Central parts depot
- o Mechanic training
- o Automotive and support vehicle repair

Operating Garage

An operating garage is a facility for storing and dispatching buses. The operating garage is the center of operations for all or part of the transit system. The operating garage offers support services essential for day-to-day operations. The maintenance capabilities of an operating garage may vary depending upon the size of the transit system and other facilities available for the servicing of buses. There are two types of operating garages: (1) inspection; and (2) division.

Inspection Garage -- An inspection garage is an operating garage which has the necessary capabilities for the day-to-day dispatching and operation of buses assigned to the facility. Administrative functions are limited to those necessary for the operation of the facility. The maintenance capabilities are limited to light maintenance activities.

Functions carried out at an inspection garage include:

- o Running repairs
- o Daily servicing
- o Inspections
- o Brake adjustments
- o Engine degreasing
- o Engine oil testing
- o Dynamometer testing
- o Minor air conditioning inspection and repair
- o Tire changing

Division Garage -- The division garage is an operating garage which acts as an administrative headquarters for part of the transit system operating out of the facility. Division garages are found in large transit systems having several operating divisions. Each division of the transit system may also have inspection garages within each division, but the division garage will have an administrative function beyond that necessary for operating the facility. The division garage will usually have an expanded range of maintenance facilities capable of handling maintenance and repair of all buses within the division even if they are dispatched and stored at another facility.

Functions carried out at a division garage typically include:

- o All functions of an inspection garage
- o Major inspection
- o All major component exchange
- o All major in-frame repairs
- o Minor body work
- o Brake relining and drum turning
- o Chassis and engine dynamometer testing
- o Major air conditioning repair

In general, transit facilities are of one of the types listed above. However, some properties, especially those operating less than 200 buses, will operate a garage as both an operating base and a main maintenance facility. In these cases, all of the functions associated with the maintenance, servicing and storage of buses are handled at the one facility.

MAINTENANCE ORGANIZATIONAL STRUCTURES

Transit systems can be grouped on the basis of their size and their facility requirements. While specific facility requirements may depend on external factors other than size, such as the availability of machine shops or other industrial facilities in the area, the following describes organizational structures typically found within the transit industry:

One Tier System -- A small transit property (less than 200 buses) with one operating garage uses a one tier system. This garage will perform the necessary functions for the daily dispatching and operation of buses. The garage will perform vehicle inspections and various light maintenance activities. Some small transit properties find it more economical to contract out heavy

maintenance work, while others find it more economical to retain heavy maintenance in-house.

Two Tier System -- A fairly large transit property (200-500 vehicles) serving a metropolitan area may use a two tier system. A two garage system may also be used by a smaller property serving two geographically separate centers. Such properties have a main maintenance facility and one or more operating garages. Often the main maintenance facility also functions as an operating garage.

Three Tier System -- A large transit property serving a major metropolitan area may use either the two tier or three tier system. In a three tier system a property will have a main maintenance facility which may stand alone or be adjacent to an operating garage. The transit property will have several operating divisions with a divisional garage acting as an administrative headquarters for each part of the system. Within each division there may be inspection garages which provide dispatching and operations functions for routes in the same section of town.

REPORT CONTENTS

This report is organized into nine chapters:

I. Introduction

II. Methodology for Determining Current Space Allocation Practices

III. Space Allocation for Administrative Services

IV. Space Allocation for Transportation Services

V. Space Allocation for Maintenance Services

VI. Bus Inspection, Servicing, Storage and Circulation

VII. Space Allocation for Heavy Maintenance Facilities

VIII. Selection of the Best Facility Alternative

Chapter II discusses the approach used to develop space allocation data for various functions that occur in a maintenance facility and discusses the limitations of the data. Chapters III, IV, and V present data on space allocation for administration, transportation and maintenance services. Distinctions between facilities operated by single facility and multiple facility transit systems are shown as appropriate.

Chapter VI discusses the size and space requirements for bus storage, circulation, inspection and servicing. These elements are found in all operating garages. The details of bus parking space requirements, bus maneuvering space and service lane space are discussed in this chapter.

Chapter VII on the Size and Space Requirements for Heavy Maintenance Facilities provides a discussion of the functional space allocation in heavy maintenance facilities. These facilities provide areas for specialized heavy maintenance tasks and short-term storage of vehicles. In large transit properties these facilities provide space for central parts storage and work shops.

Chapter VIII covers the methods used by transit systems to select the best facility alternative. Two economic analysis methods, net present worth and annual costs, are discussed. Methods used to select the best location for a maintenance facility are also discussed.

II. METHODOLOGY FOR DETERMINING CURRENT SPACE ALLOCATION PRACTICES

The purpose of this chapter is to describe the approach used to develop space allocation practices. This chapter discusses the study methodology and related issues, specifically:

- o Criteria for Selection of Sites for Data Collection
- o Data Collection Procedures
- o Analysis Methods
- o Research Assumptions and Limitations

SELECTION OF SITES FOR DATA COLLECTION

The purpose of this project is to develop guidelines for planning bus maintenance facilities. The first step in the project was to evaluate maintenance space allocation in modern transit maintenance facilities. Modern facilities were defined in this study as those which were built within the last fifteen years. Records from UMTA Regional Offices and articles in transit industry journals were used to identify sites with new facilities.

To guide this evaluation, factors mentioned in the literature on transit maintenance facilities as significant in space allocation were identified. The facilities that were selected for evaluation were chosen to facilitate analysis of these factors.

Fleet size is the common factor that is mentioned in the existing literature on transit maintenance facility planning. Modern facilities were selected to cover the full range of fleet sizes, up to a maximum of roughly 350 buses. An effort was also made to select facilities at smaller transit systems (i.e. less than seventy-five buses), because little had been written in the current literature on these systems.

The literature review also indicated differences in maintenance facilities between single facility transit systems and multiple facility transit

systems. In order to control for this variable, a mix of facilities from single facility systems and multiple facility systems were selected. Since heavy maintenance facilities are often built in multiple facility systems, a selected number of these facilities were identified.

Finally, climate was expected to be a factor, particularly in regard to bus storage. Transit systems from all parts of the country were selected in order to include a wide range of climate types in the data set.

Using these selection criteria, 33 transit maintenance facilities were selected. Data were collected on the seventeen single facility maintenance garages (Table II-1), eleven multiple facility maintenance garages (Table II-2) and five heavy maintenance facilities (Table II-3)

DATA COLLECTION

Data were obtained through site visits to twelve facilities, telephone conversations with maintenance and engineering personnel in all cases, and by mail. Initially, information was sought from transit systems on the space guidelines that were used in the planning of their facilities. Unfortunately, only a small number of transit systems had this information, and often, the information was not complete. Since initial reviews of the new facilities suggested that planning guidelines were used in their design, the data collection effort was organized to collect detailed information on the new facilities. It was hoped that statistical analysis could be used to "derive" the planning guidelines that were used. The detailed information that was collected fell into the following three categories:

- o Facility Description: As-built drawings were obtained for each facility. Space allocated to various functions was scaled from the prints. The number of pits, lifts, special bays, etc. were counted and cross-checked against telephone interview data. Architectural information on materials, heating systems, air conditioning, lighting and energy management were obtained both from the prints and from interviews.

TABLE II-1

SINGLE FACILITY TRANSIT SYSTEMS WITH NEW BUS MAINTENANCE AND STORAGE FACILITIES

Transit System	Location	Assigned Fleet
Metro Regional Transit Authority	Akron, OH	129
Sun Tran	Albuquerque	107
Chapel Hill Transit	Chapel Hill, NC	48
Chattanooga Area Regional Transit Authority	Chattanooga, TN	69
Central Ohio Transit Authority	Columbus, OH	322
Metropolitan Transit Authority	Des Moines, IA	100
Duluth Transit Authority	Duluth, MN	95
Public Transit Administration of El Paso	El Paso, TX	150
Transit Authority of Northern Kentucky	Fort Wright, KY	96
Island Transit	Galveston, TX	15
Jacksonville Transportation Authority	Jacksonville, FL	267
Madison Transit Department	Madison, WI	187
Transit Authority of Omaha	Omaha, NB	197
Escambia Transit System	Pensacola, FL	29
Capital Area Transit	Raleigh, NC	58
County of Lackawanna Transit System	Scranton, PA	36
Delaware Administration for Regional Transit	Wilmington, DE	100

TABLE II-2

MULTIPLE FACILITY TRANSIT SYSTEMS WITH NEW OPERATING GARAGES

Transit System	Location	Assigned Fleet	Facility Name
Regional Transportation District	Aurora, CO	208	East Metro
Massachusetts Bay Transportation Authority	Boston, MA	145	Cabot Garage
Regional Transportation District	Boulder, CO	106	Boulder Bus Facility
Niagara Frontier Transportation Authority	Buffalo, NY	120	Frontier Division
Regional Transportation District	Denver, CO	233	Platte Division
Regional Transportation District	Longmont, CO	12	Longmont Bus Facility
Transit Authority of River City	Louisville, KY	211	Union Station Division
Phoenix Transit	Phoenix, AZ	93	North Satellite Facility
Washington Metropolitan Area Transit Authority	Rockville, MD	147	Nicholson Lane Metrobus Facility
Capital District Transportation Authority	Schenectady, NY	44	Schenectady Garage
Capital District Transportation Authority	Troy, NY	67	Troy Garage

TABLE II-3

HEAVY MAINTENANCE FACILITIES
MULTIPLE FACILITY TRANSIT SYSTEMS

Transit System	Location	Assigned Fleet	Facility Name
Capital District Transportation Authority	Albany, NY	230	Watervliet Garage
Metropolitan Atlanta Rapid Transit Authority	Atlanta, GA	740	Brown's Mill Maintenance Facility
Metropolitan Transit Commission	Minneapolis, MN	1,000	Overhaul Base
Municipality of Metropolitan Seattle Transit Department	Seattle, WA	330	Central Operating Base
Phoenix Transit	Phoenix, AZ	250	South Maintenance Facility

- o Operations Data: Operations data were assembled so that relationships could be tested between facility space allocation and the characteristics of the transit system as reflected in operations data. Items like fleet size, annual vehicle miles, peak-to-base ratio, spare vehicle ratio, and miles between road calls were assembled.

- o Personnel Data: Personnel rosters for administration, operations and maintenance were obtained from the participating transit systems. These data were also used in searching for relationships between space allocation and transit system characteristics.

ANALYSIS METHODS

The analysis of transit maintenance facilities was organized according to three general areas of a transit system -- Administration, Transportation and Maintenance. All operating garages have a transportation department. This consists of offices for supervisors and dispatchers plus a common area for drivers. Almost every operating garage has maintenance support facilities, service lanes for fueling and cleaning, and a vehicle storage area. The amount of maintenance support varies, depending on how maintenance work is allocated throughout the transit system. Finally, some administrative support is quite often present on-site. Once again the degree of administrative support on-site varies, because all administrative personnel are not necessarily housed at maintenance facilities.

The analysis involved testing hypothesized relationships for different types of facility space. For instance, administrative office space was hypothesized to be related to the number of administrative personnel on-site. Transportation space was thought to be related to fleet size or to the number of drivers. Maintenance space was assumed to be related to annual vehicle miles or to fleet size. These simple relationships were plotted to observe the closeness of the hypothesized relationship. If the relationship appeared linear, a regression equation was calculated.

If the plot suggested that the hypothesized relationship was not supported by the data, the data were rechecked. If no data problems were discovered, a correlation table of all the data collected was produced to identify any other potential explanatory variables. Plots were tried on these variables and multiple regressions tried where appropriate. Non-linear equations were tried when plots suggested non-linear relationships between the variables.

The results of this analysis are described in Chapters III to VII. When useful relationships could be identified, they are reported in these chapters. When no useful relationship could be identified, simple means are shown with high and low values to indicate the range of variables which were expected to be related to the space provided. Explanations for the lack of a relationship when one might be expected are also offered.

In general, the analysis shows that aggregate space allocation does in fact conform to hypothesized relationships. Administrative space is related to administrative personnel on site; aggregate transportation space is related to the fleet size, and aggregate maintenance space is related to annual vehicle miles. Subareas within each primary component showed much more variation, however, and typically could not be expressed in mathematical form.

One explanation for some of the apparent randomness is that space allocation for some activities is not directly affected by system size. The amount of room required by one person to work effectively is the controlling variable and the space allocation is more or less the same regardless of the total facility size. Small support shops fall into this category -- injector shop, electrical shop, welding shop, parts cleaning, and steam cleaning.

RESEARCH ASSUMPTIONS AND LIMITATIONS

This is a State-of-the-Practice report. The data presented here reflect maintenance space allocation in the context of current practice. Any use of these data for planning purposes in situations where background conditions are very different could result in error. Some of the key conditions and limitations of this report are discussed in the following paragraphs.

Work Shifts

All of the transit systems visited do the majority of maintenance work on the day shift. The second shift is primarily concerned with fueling, cleaning and light repair. The light repair work on second shift concentrates on correcting minor defects discovered during inspection so that these vehicles can be used the next day. The night shift is almost universally small. If a full night shift was operated in maintenance, more vehicles could obviously be maintained in the same work space. This is not current practice. Relationships between maintenance space and operating fleet reflect this utilization of manpower.

Use of As-Built Drawings

As-built drawings of maintenance facilities were used to determine the allocation of work space to various functions. The labelling on the drawings did not always provide sufficient detail for maintenance subareas. For instance, an area labelled "machine shop" might actually accommodate overhaul work, small unit repair and electrical repair in an open area. Other facilities might have small unit repair and electrical repair in separate rooms labelled on the drawing. In the latter case a space allocation could be scaled from the print for all three functions, whereas in the former case this level of accuracy could not be obtained. While follow-up calls were made to

clear up as many questions as possible, the degree to which functional spaces are separated and labelled on as-built drawings affects the degree of detail obtainable. This may account for the lack of strong statistical relationships among smaller maintenance subareas.

Articulated Buses

There is much interest in articulated buses today, but most transit properties in the data set do not have oversized bays for articulated buses. The analysis in this report reflects the state-of-the-practice among properties operating standard buses. If a facility is being planned to accommodate a large percentage of articulated buses, space allocation may be greater than suggested here.

Capacity Versus Current Fleet

In describing relationships between space allocation and measures of facility size, the question arises as to whether the planned capacity or the resident fleet is the most appropriate descriptive variable. In this report, current measures have been selected -- current fleet, current annual vehicle miles, current personnel, etc.

III. SPACE ALLOCATION FOR ADMINISTRATIVE SERVICES

The administrative services area provides space for the administrative support functions conducted at bus maintenance and storage facilities. These functions may include:

- o Administration
- o Accounting
- o Planning
- o Traffic and Safety
- o Marketing
- o Schedules
- o Public Relations
- o Public Information
- o Personnel
- o Data Processing
- o File Storage
- o Credit Union Services
- o Instruction
- o Security
- o First Aid
- o Miscellaneous

Not all of these functions are carried out in every administrative office. The size and structure of the transit system largely determine what functions are included in the administrative component.

The following facilities may be part of the administrative services area:

- o General manager's office
- o Assistants offices
- o Secretaries and clerks offices
- o Comptroller's office
- o Personnel office
- o Files storage room
- o Rest rooms
- o Public information center
- o Data processing room
- o Classrooms
- o Other

Depending on the size and structure of the transit system some of the above areas may or may not be part of a particular administrative office area. For example, the General Manager's office may be located at the administrative headquarters of the transit system and not at an operating facility. Smaller transit systems may utilize one large room as both a class/training room and the conference room. Figure III-1 displays the administrative floor plan for Wilmington, Delaware, maintenance facility. This is typical of an administrative office space layout for a middle-sized transit system.

SPACE AVAILABLE

Among the facilities observed there is a relationship between the number of administrative employees located on-site and the total space provided for the administrative services area. Transit systems often locate administrative employees at several sites. This study only includes data for administrative space and employees located at the maintenance and storage facilities.

More office space for administrative functions is provided in transit systems with only a single maintenance facility than in systems with multiple facilities. An average of 7,100 square feet of administrative space was provided in single facility systems while only 1,900 square feet was provided in multiple facility systems. The reason for this difference is that multiple facility are more likely than single facility systems to maintain separate administrative offices away from the maintenance facility.

While the gross amount of administrative space differed between the two system types, there was no difference in the amount of space that was provided per administrative employee. Approximately 260 square feet per administrative employee was provided in both single and multiple facility systems. The use of administrative employees as the independent variable was found to provide the best statistical relationship for administrative space (Figure III-2).

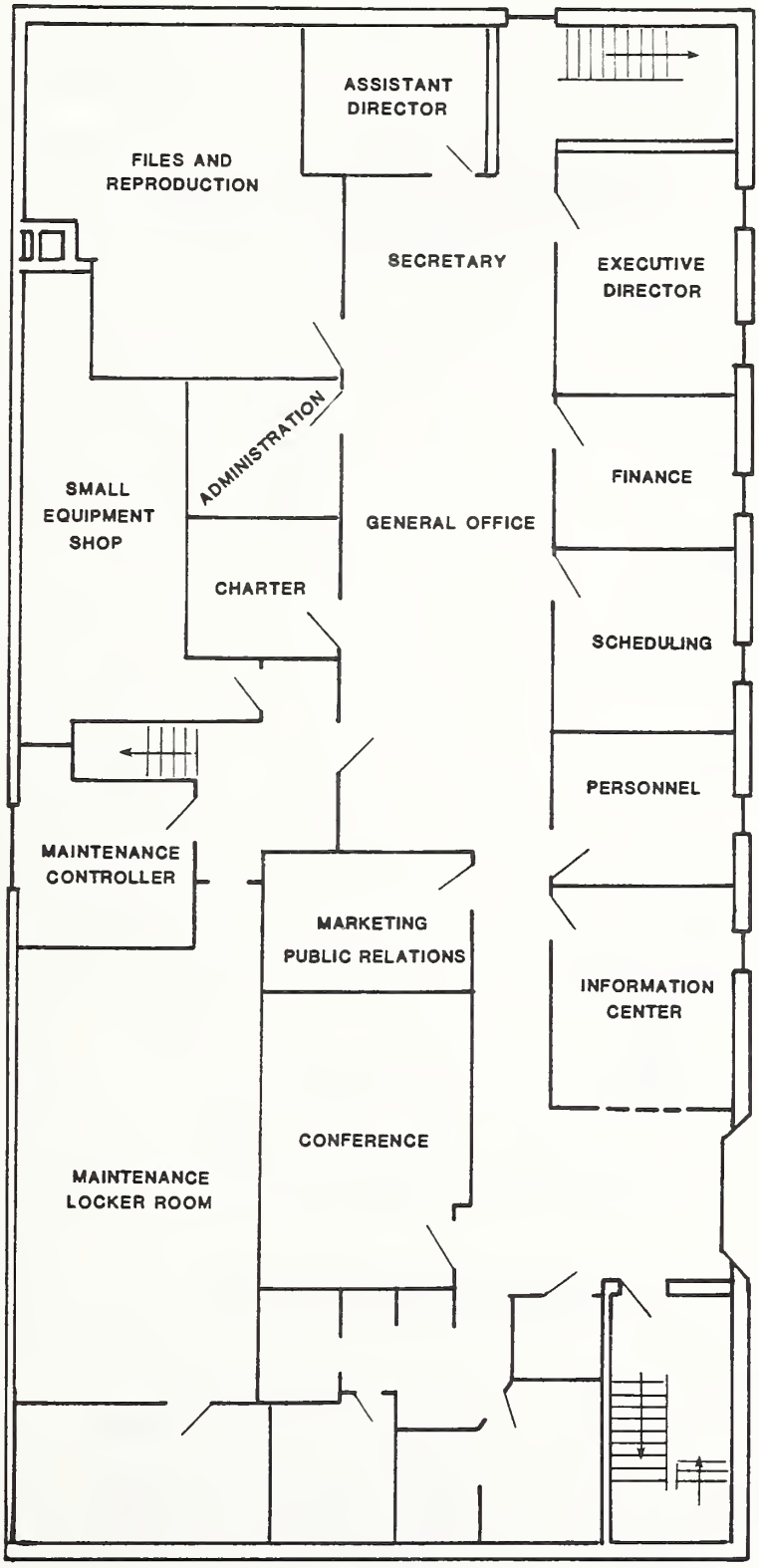
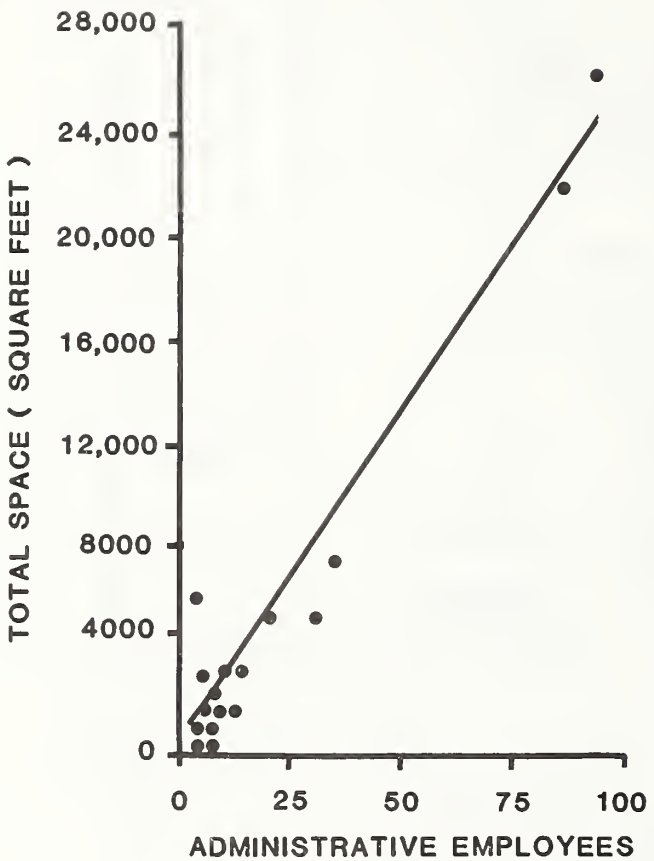


FIGURE III-1

ADMINISTRATIVE COMPONENT
WILMINGTON, DELAWARE

FIGURE III-2

ADMINISTRATIVE SPACE ANALYSIS
ALL FACILITIES



TOTAL ADMINISTRATION SPACE
REGRESSION EQUATION

$y = 258x + 752$

(15) (460)	STANDARD ERROR OF REGRESSION COEFFICIENT
(17.15) (1.64)	T-VALUE
(0.00) (0.06)	SIGNIFICANCE OF T-VALUE
$r^2 = 0.94$	NUMBER OF CASES = 20

x = ADMINISTRATIVE EMPLOYEES ON SITE
y = TOTAL ADMINISTRATIVE SPACE IN SQUARE FEET

No direct relationship could be found between the size of specific administrative rooms and the number of administrative employees located at the facility. As shown in Table III-1, the amount of space appeared to increase as the number of administrative employees increased. However, the number of observations was small and the range of values for each category was large, so that this observation could not be statistically shown.

Transit properties serving large metropolitan areas generally locate their administrative headquarters at office buildings located apart from bus maintenance and storage facilities. Among most of the observed facilities the on-site administrative staff consisted of two or three people --- the garage manager and his support staff of one to two clerks and secretaries.

As shown in Table III-2, the amount of administrative space varied greatly among the multiple facility sites that were analyzed. The analysis suggests that there is no industry consensus on the amount of administrative space that should be provided in facilities at multiple facility transit systems. Instead, it appears that management and/or architects preferences dictate the amount of space that is provided.

TABLE III-1

ADMINISTRATIVE SPACE AVAIABLE
SELECTED KEY ROOMS

	Range of Administrative Space Available (Square Feet)		
	Less Than 20 Employees	21-50 Employees	50-100 Employees
Manager's Office	150-350	350-385	475
Conference Room	170-400	400-460	1,600
Employee Support	50-380	215-575	475
Passenger Services	0-225	75-225	3,550
Storage	75-700	75-150	3,725
Number of Observations	7	3	1

Employees are administrative employees on site only.

TABLE III-2

ADMINISTRATIVE SPACE AVAILABLE
MULTIPLE FACILITY PROPERTIES

Location	Fleet Size	Administrative Employees Located On-Site	Administrative Space Per Employee (Square Feet/Employee)	Space Available (Square Feet)			
				Offices	Storage	Conference Room	Manager's Office
Longmont, CO	12	0	—	178	135	171	132
Schenectady, NY	44	3	337	642	0	0	324
Troy, NY	67	3	616	210	0	385	221
Phoenix, AZ	93	3	125	1,080	950	885	520
Boulder, CO	106	3	1,095	1,591	238	267	285
Buffalo, NY	120	0	—	1,104	0	0	480
Boston, MA	145	3	1,069	2,451	357	0	0
Rockville, MD	147	2	320	320	0	0	320
Aurora, CO	208	8	370	1,238	207	256	0
Louisville, KY	211	3	—	0	0	0	0
Denver, CO	233	8	230	1,840	0	0	0

IV. SPACE ALLOCATED FOR TRANSPORTATION SERVICES

Space for transportation services is provided in all operating garages. Transportation services include all activities related to the daily implementation of scheduled transit service. Space is typically provided in the transportation services area for operator support, dispatching, and supervision activities. The transportation services area is usually located near the bus staging and return areas to minimize the time operators spend walking to and from their vehicles. Operators are often required to report to this area twice a day, at the beginning and end of their work assignments.

The areas typically included in the transportation services area are:

- o Superintendent of transportation's office
- o Dispatcher's office
- o Clerks and street supervisors' office
- o Train room (also known as drivers' room, bull pen, report room, etc.)
- o Lunch and recreation areas
- o Quiet room
- o Locker rooms
- o Radio room
- o Rest rooms

SPACE AVAILABLE

A relationship was found between the size of the transportation services area and the size of the assigned fleet. A distinction between single facility and multiple facility transit systems was not found to be meaningful in this analysis, since partitioning the data set into these two categories did not improve the correlation between fleet and transportation space

allocation. As shown in Figure IV-1, approximately 900 square feet plus 22 square feet per assigned bus was derived as a reasonable planning guideline for estimating the total space requirements for transportation services.

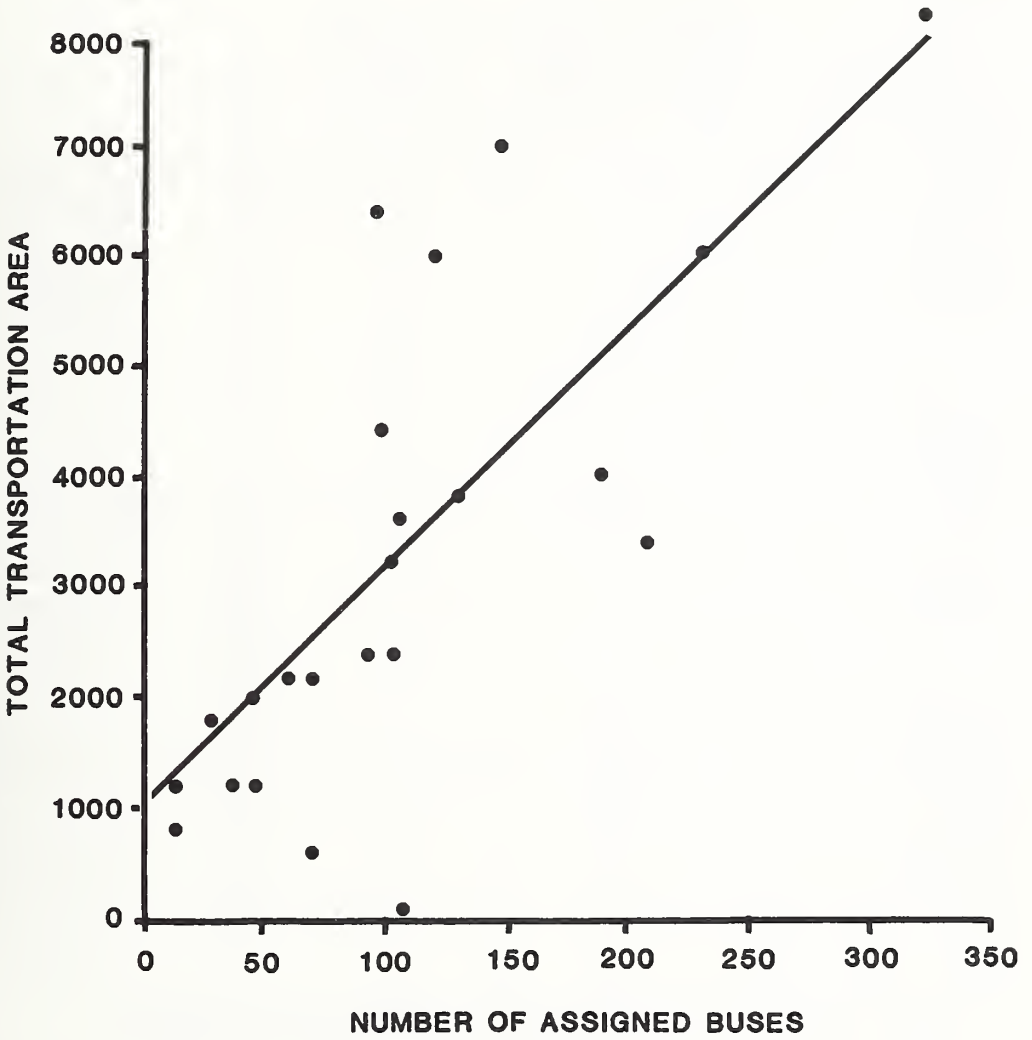
The number of operations personnel, drivers and operational support personnel, was hypothesized to a more reasonable basis than fleet size in determining the size of the transportation services area. The number of drivers, for example, would seem to be the most important consideration when designing specific areas such as locker rooms which must provide facilities to accommodate the total number of drivers assigned to the facility. In the data analysis, however, assigned fleet shows the best relationship with total transportation services space.

No clear mathematical relationships were found between space provided for specific subareas and independent variables such as assigned bus fleet or number of drivers Characteristics of the service operated out of the facility such as peak to base ratio, service hours and operations schedules were considered; however, the data were not available for all characteristics and no descriptive equations could be developed from the data.

As shown in Tables IV-1 and IV-2, a wide range of values were found for specific service areas. The ratio of train room space, an area where drivers report for duty and prepare reports on their assignments, to the number of drivers ranged from one to twenty-seven square feet per driver. This wide range may reflect the differences in reporting practices among the systems analyzed.

Locker room space ranged from four to eleven square feet per driver among the observed facilities. The mean value was seven square feet per driver. Locker rooms provide facilities for all drivers assigned to the facility. Since the overall size of the locker room should provide enough floor space

FIGURE IV-1
TRANSPORTATION SPACE VS FLEET SIZE



TRANSPORTATION SPACE REGRESSION EQUATION

$y = 22x + 938$

(4)	(553)	STANDARD ERROR OF REGRESSION COEFFICIENT
(5.18)	(1.70)	T-VALUE
(0.00)	(0.05)	SIGNIFICANCE OF T-VALUE

$r^2 = 0.56$ NUMBER OF CASES = 23

x = FLEET SIZE

y = TRANSPORTATION SPACE IN SQUARE FEET

TABLE IV-1

TRANSPORTATION SPACE ALLOCATION
DRIVER-RELATED AREAS

Location	Fleet	Drivers	Ratio of Train Room Space To Drivers (Square Ft./Driver)	Ratio of Locker Room Space To Drivers (Square Ft./Driver)	Ratio of Classroom Space To Drivers (Square Ft./Driver)	Ratio of Lunchroom Space To Drivers (Square Ft./Driver)
Longmont, CO	12	36	21	—	—	—
Galveston, TX	15	19	15	—	19	—
Pensacola, FL	29	35	27	—	9	—
Scranton, PA	36	54	—	—	—	—
Schenectady, NY	44	57	—	—	—	—
Chapel Hill, NC	48	60	—	5	4	—
Raleigh, NC	58	73	10	8	—	—
Troy, NY	67	83	9	6	—	—
Chattanooga, TN	69	59	—	—	—	—
Phoenix, AZ	93	105	19	11	—	8
Duluth, MN	95	108	1	3	7	11
Fort Wright, KY	96	116	3	7	3	4
Des Moines, IA	100	105	6	—	10	—
Wilmington, DE	100	114	8	—	—	—
Boulder, CO	106	94	9	11	5	3
Buffalo, NY	120	160	3	7	—	3
Akron, OH	129	163	6	—	5	5
Boston, MA	145	400	1	6	3	13
Rockville, MD	147	200	11	—	2	
Madison, WI	187	217	13	—	—	—
Omaha NB	197	230	5	—	1	4
Aurora, CO	208	282	8	—	2	—
Louisville, KY	211	284	4	4	—	2
Denver, CO	233	299	10	4	—	—
Columbus, OH	322	428	6	—	—	—
Mean Value*			9	7	6	6

* Mean values are based only on those locations allocating space to the functional area.

Note: Missing values indicate that the area was not housed in the building for which data were obtained. Many bus operations utilize several buildings to house various functions. This study assembled data only on buildings that include maintenance.

TABLE IV-2

TRANSPORTATION SPACE ALLOCATION
NON-DRIVERS AREAS

Location	Fleet	Personnel Support Personnel	Ratio of Office Space to Operations Support Personnel (Square Feet/Person)	Radio Dispatch Area (Square Feet)
Longmont, CO	12	4	—	144
Galveston, TX	15	1	—	169
Pensacola, FL	29	3	—	350
Scranton, PA	36	4	—	200
Schenectady, NY	44	5	—	200
Chapel Hill, NC	48	9	66	134
Raleigh, NC	58	3	53	196
Troy, NY	67	6	—	565
Chattanooga, TN	69	6	49	—
Phoenix, AZ	93	8	115	497
Duluth, MN	95	10	12	512
Fort Wright, KY	96	11	155	832
Des Moines, IA	100	11	143	—
Wilmington, DE	100	9	70	411
Boulder, CO	106	14	17	395
Buffalo, NY	120	5	—	—
Akron, OH	129	7	—	269
Boston, MA	145	4	744	160
Rockville, MD	147	5	288	—
Madison, WI	187	9	52	840
Omaha NB	197	12	314	1,118
Aurora, CO	208	9	24	—
Louisville, KY	211	3	397	1,096
Denver, CO	233	9	171	—
Columbus, OH	322	13	450	—
Mean Value*			184	449

* Mean values are based only on those locations allocating space to the functional area.

Note: Missing values indicate that the area was not housed in the building for which data were obtained. Many bus operations utilize several buildings to house various functions. This study assembled data only on buildings that include maintenance.

for the maximum number of drivers on-site at any one time, the wide range of values may reflect different peaking characteristics among the systems analyzed.

Classroom/training space ranged from one to nineteen square feet per driver. The mean value for this space was six square feet per driver. Lunch room space per driver ranged from two to thirteen square feet per driver. Six square feet per driver was the mean value for space allotted to this area.

Office space for operations support personnel ranged from 17 square feet per person in Boulder, Colorado, where there is relatively little space allocated for a staff of 14 support personnel, to 744 square feet per person in Boston, Massachusetts, for a staff of four support personnel. The mean value was 184 square feet per person.

The radio/dispatch office, usually an area which acts as the operations and communications center for buses operating out of the facility, ranged in size from 144 to 1,118 square feet. The space allotted to this area appeared to vary according to the structure of the operations support functions. Central radio/dispatch centers may include an extensive communication center (e.g. telephone answering, information services) especially at larger transit systems with more than one facility. In others, particularly smaller transit systems, radio/dispatch activities may be the only function housed in the area.

In summary, while the size of the bus fleet located at a facility was shown to be a good estimator of the required size of the transportation services area, there may be other factors that affect the amount of space allocated to this area. This accounts for the lack of statistical relationships between specific areas and likely independent variables. Service characteristics and management policies may affect the size of the transportation component. Some systems may have different peak demands for areas like

train rooms and locker rooms. Management policies and past practices among systems may vary. One system may be more generous in the amount of space that is provided for driver support areas.

V. SPACE ALLOCATION FOR MAINTENANCE SERVICES

The maintenance area is where all bus maintenance and repair is conducted. In this analysis maintenance includes parts and storage rooms, repair bays, shop area, service area and inspection area. This chapter covers all areas of maintenance except service and inspection. Chapter VI provides a detailed analysis of the service and inspection areas.

The largest space within the maintenance component is the maintenance bay area. This area provides bus bays equipped to handle various activities associated with bus maintenance and repair. Other maintenance areas are used for vehicle and component testing, storage and personnel support. Some areas within the maintenance section are able to support a wide range of functions while other specialized areas are equipped to support specific functions. The nature of the tasks conducted in the various areas determines the equipment, construction and location requirements for each space. Vehicle painting, vehicle testing and parts cleaning are examples of activities which require special equipment and enclosed areas to maintain acceptable environmental conditions throughout the facility.

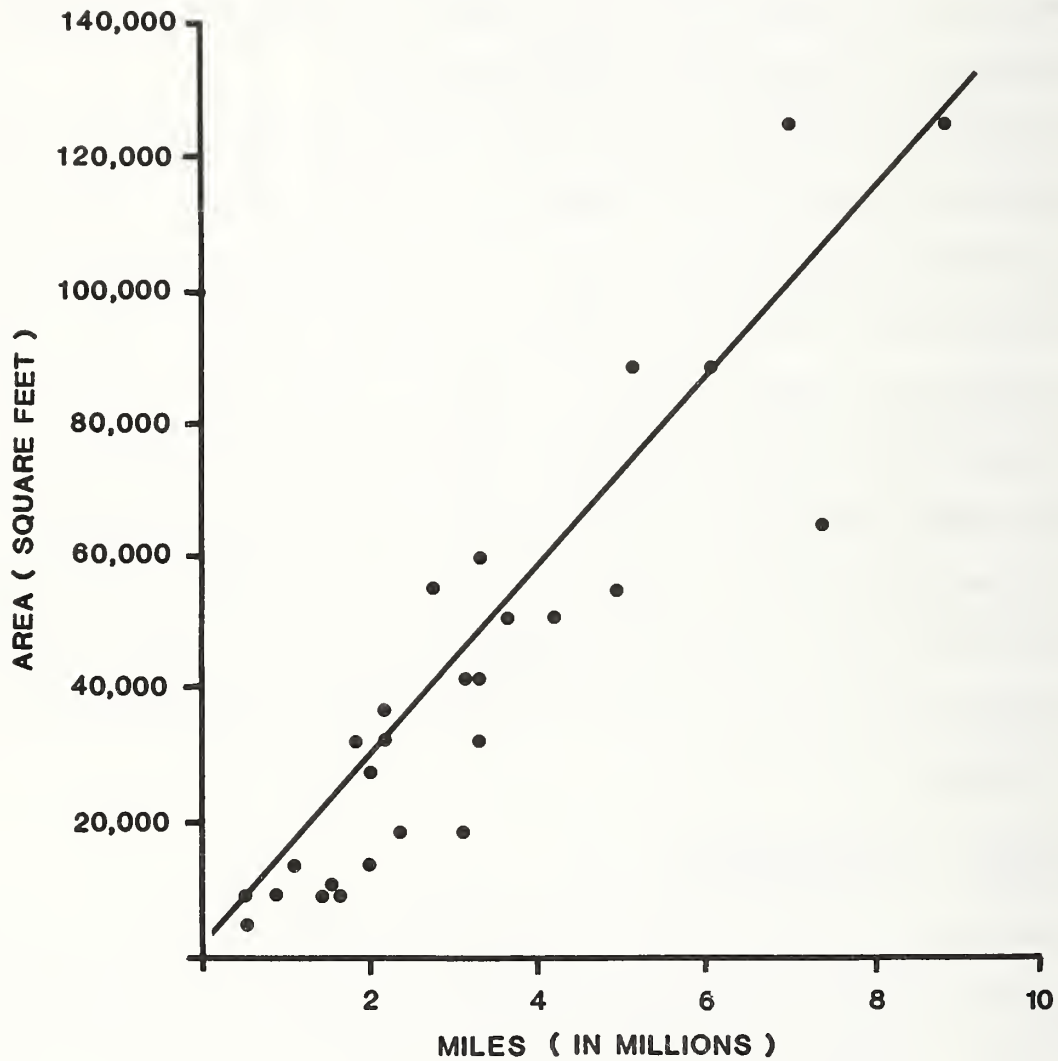
MAINTENANCE SHOP — SPACE AVAILABLE

A relationship was found in the analysis between the size of the maintenance area and the level of service provided. Among the transit systems examined, total maintenance area displayed the best relationship to total vehicle miles operated. As shown in Figure V-1, a planning guideline of 1,400 square feet per 100,000 miles operated was derived in the analysis.

The relationship between annual vehicle miles and the space allocated for the total maintenance area was found to be an accurate estimator of observed maintenance space for garages operated by both single facility and multiple

FIGURE V-1

TOTAL MAINTENANCE AREA VS ANNUAL VEHICLE MILES



TOTAL MAINTENANCE AREA REGRESSION EQUATION

y = 1389x + 564

(129)	(4763)	STANDARD ERROR OF REGRESSION COEFFICIENT
(10.81)	(0.12)	T-VALUE
(0.00)	(0.45)	SIGNIFICANCE OF T-VALUE

r^2 = 0.82 NUMBER OF CASES = 27

x = ANNUAL VEHICLE MILES IN 100,000'S

y = TOTAL MAINTENANCE AREA IN SQUARE FEET

facility transit systems. However, among maintenance subareas, distinctions were found between facilities at transit systems operating one facility (single-facility systems) and transit systems operating more than one facility (multiple-facility systems). While the total space allocated for maintenance was found to be related to vehicle miles across all of the facilities observed, the space allocation of some subareas was found to be different when comparing single-facility and multiple-facility systems.

Among the multiple-facility systems observed, operating garages typically include a large maintenance bay area with a few selected rooms providing maintenance support space. Specialized repair functions take place at heavy maintenance shops located elsewhere, so there is no need to provide space for all specialized repair functions in operating garages. Maintenance support areas typically found in operating garages operated by multiple facility transit systems include a steam cleaning area, battery storage room, tire shop, and maintenance personnel support areas.

At single facility systems, operating garages include more maintenance support space. In addition to the areas mentioned above, space is provided for a body shop, paint shop, overhaul shop, and, sometimes, specialty areas like an electrical shop or injector room. Because all maintenance for an entire transit system is provided at one location, more specialized maintenance support areas are to be found than at operating garages in multiple facility transit systems.

A summary of the analysis of the space provided for specific maintenance functions is provided in the remaining sections of this chapter. The sections are organized by the variables which were found statistically to be the best estimators of space provided for each function.

The size of some maintenance areas was found to be best estimated by the annual vehicle miles operated out of the facility. The next section includes a discussion of these areas which include:

- o Maintenance Bay Area
- o Parts Storage
- o Maintenance Storage

The following section covers areas for which no statistical relationships could be found. The size of these areas does not appear to be related to any characteristics of the facility such as annual vehicle miles or fleet size. These areas exhibit a great deal of variation due to building layout and the volume of work contracted. Some small shop areas are governed by the size of the equipment and the space required for a person to work comfortably, not by the volume of work. It was not possible to control for all of these variables statistically, so clear relationships to hypothesized independent variables could not be established. Examples of these areas include:

- o Tire Shop/Storage
- o Overhaul Shop
- o Paint and Body Shop
- o Brake Repair Shop
- o Welding Shop
- o Injector Repair Shop
- o Electric Shop
- o Battery Room
- o Steam Clean Area
- o Dynamometer Area
- o Parts Cleaning Area
- o Maintenance Offices
- o Mechanics' Locker Room
- o Mechanics' Lunch Room
- o Employee Support (vending areas, rest rooms, etc.)

MILEAGE-RELATED AREAS

Mileage-related maintenance areas are those for which space allocation was found to be best estimated by the annual vehicle miles operated out of a facility. The maintenance bay area and storage areas fall into this category.

MAINTENANCE BAY AREA

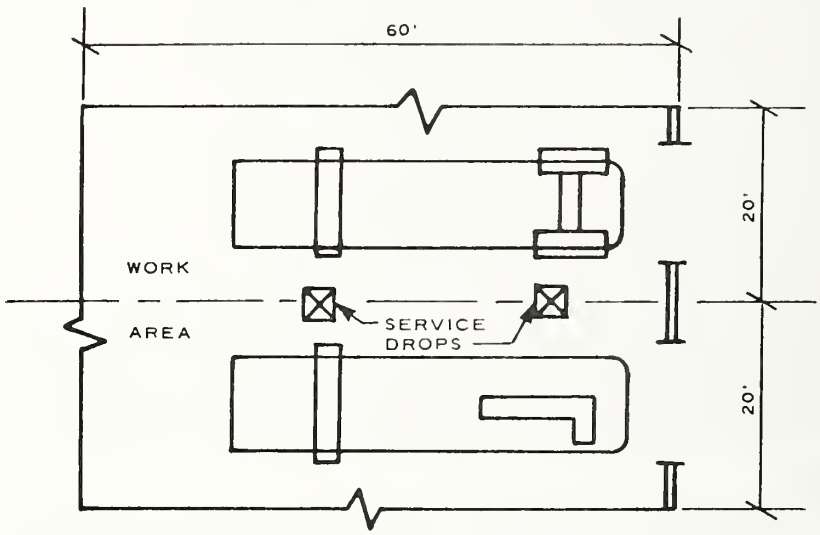
The maintenance bay area is where the primary maintenance functions are conducted. Bus bays are usually equipped with wheel lifts, axle lifts, or pits. Figure V-2 illustrates a typical two position repair area, showing typical dimensions.

Number of Work Bays Available

Among the observed facilities the tendency was to assign functions to particular bays, when possible, although maintenance bays are generally equipped to handle a wide range of functions. To provide this flexibility, repair bays are about the same size and are equipped to carry out most maintenance functions. Exceptions to this policy are the body repair bays, painting bays, steam cleaning bays and dynamometer bays where the nature of the work requires a separate area with specialized equipment. These areas are analyzed later in this section and are not included in this discussion of the maintenance bay area.

Unenclosed bays are assigned functions by the maintenance manager or foreman. In practice, a bay is assigned to a single kind of work (e.g. brakes) if the work volume warrants it. Tasks that are too infrequent to warrant a dedicated bay are assigned on an as-needed basis; if space is available in the bay area it is utilized for whatever functions the open bay can accommodate. For example, air conditioning repair bays are often used for a whole range of other maintenance activities if the space is available.

Bays are enclosed when special equipment is needed or safety is of concern as with dynamometers, painting or steam cleaning. These work bays are designed for specific functions and are devoted to the tasks for which they are designed as a matter of practice. In most cases, with the exception of body repair bays, only one bay is allocated for the tasks if the space is



SOURCE: BUS GARAGE STANDARDIZATION AND REHABILITATION FOR THE CHICAGO TRANSIT AUTHORITY, AUGUST 1977.

FIGURE V-2

REPRESENTATIVE TWO-POSITION REPAIR AREA SHOWING TYPICAL DIMENSIONS AND LAYOUT

provided in the facility. As shown in Table V-1 about twenty percent of total maintenance bays are specialized bays at single facility transit systems.

At multiple facility transit systems operating garages perform fewer specialized activities. Specialized maintenance and repair functions are usually conducted at a main maintenance facility. As a result only general repair bays were found at multiple facility sites as shown in Table V-2.

The number of non-specialized maintenance bays in a facility shows a good relationship to the annual vehicle miles of service operated out of garages in both single and multiple facility transit systems. As shown in Figure V-3, a relationship of 2.34 general repair bays per million vehicle miles plus a constant of 3.79 represents current practice.

Space Available -- Maintenance Bay Area

A statistical relationship for the maintenance bay area was only found for single facility systems. The best relationship for single facility systems was 5,600 square feet plus 250 square feet per 100,000 annual vehicle miles (Figure V-4).

A similar relationship (5,800 square feet + 230 square feet per 100,000 vehicle miles) was observed for multiple facility systems; however, the coefficient of determination was poor ($R^2 = 28$). The poor relationship for multiple facility systems may be attributed to the small number of cases (eight) in which data were available and to differences in the maintenance programs among the systems.

PARTS ROOM

The parts room provides space for storage, inventory and exchange of small parts and maintenance supplies. The parts room usually contains parts bins and shelving for storing items needed on a regular basis. In facilities

TABLE V-1

MAINTENANCE BAYS
SINGLE FACILITY TRANSIT SYSTEMS

Location	Fleet	Vehicle Miles Operated [1/]	Total Maintenance Bays [2/]	Non-Specialized Bays
Albuquerque, NM	107	3,000,000	11	9
Akron, OH	129	3,465,000	10	8
Chapel Hill, NC	48	780,000	4	4
Chattanooga, TN	69	1,600,000	13	11
Columbus, OH	322	8,700,000	29	22
Des Moines, IA	100	2,100,000	17	13
Duluth, MN	95	2,083,300	14	10
El Paso, TX	150	3,991,820	16	11
Fort Wright, KY	96	3,000,000	18	15
Galveston, TX	15	435,676	4	3
Jacksonville, FL	267	3,000,000	25	16
Madison, WI	187	4,977,690	13	12
Omaha, NB	197	6,000,000	28	25
Pensacola, FL	29	964,000	7	6
Raleigh, NC	58	1,476,850	5	4
Scranton, PA	36	1,271,340	10	8
Wilmington, DE	100	2,212,340	12	10

1. Includes all maintenance bays including those utilized for inspection.

2. Excludes body shop bays, paint bays, dynamometer bays and alignment bays. Steam clean bays are included.

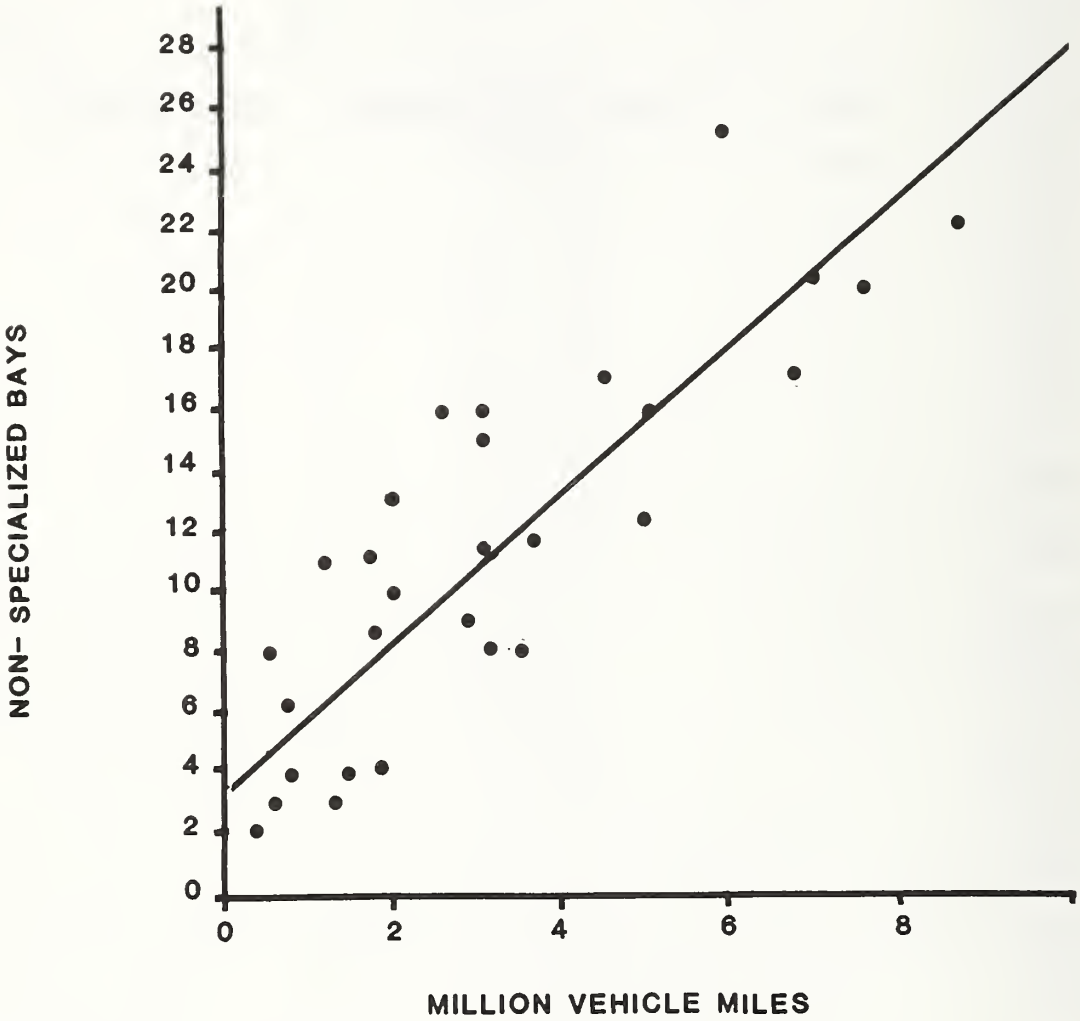
TABLE V-2

MAINTENANCE BAYS
MULTIPLE FACILITY TRANSIT SYSTEMS

Location	Fleet	Vehicle Miles Operated	Maintenance Bays
Aurora, CO	208	6,755,970	17
Boston, MA	145	3,128,720	11
Boulder, CO	106	3,082,980	8
Buffalo, CO	120	2,600,000	16
Denver, CO	233	7,257,000	20
Longmont, CO	12	349,016	2
Phoenix, AZ	93	1,937,500	11
Rockville, MD	147	4,836,070	16
Schenectady, NY	44	1,490,000	3
Troy, NY	67	1,880,000	4

FIGURE V-3

NON-SPECIALIZED MAINTENANCE BAY
VS ANNUAL VEHICLE MILES



NUMBER OF MAINTENANCE BAYS REGRESSION EQUATION

$y = 2.34x + 3.79$

(0.31) (3.41) STANDARD ERROR OF REGRESSION COEFFICIENT

(7.48) (1.11) T-VALUE

(0.00) (0.30) SIGNIFICANCE OF T-VALUE

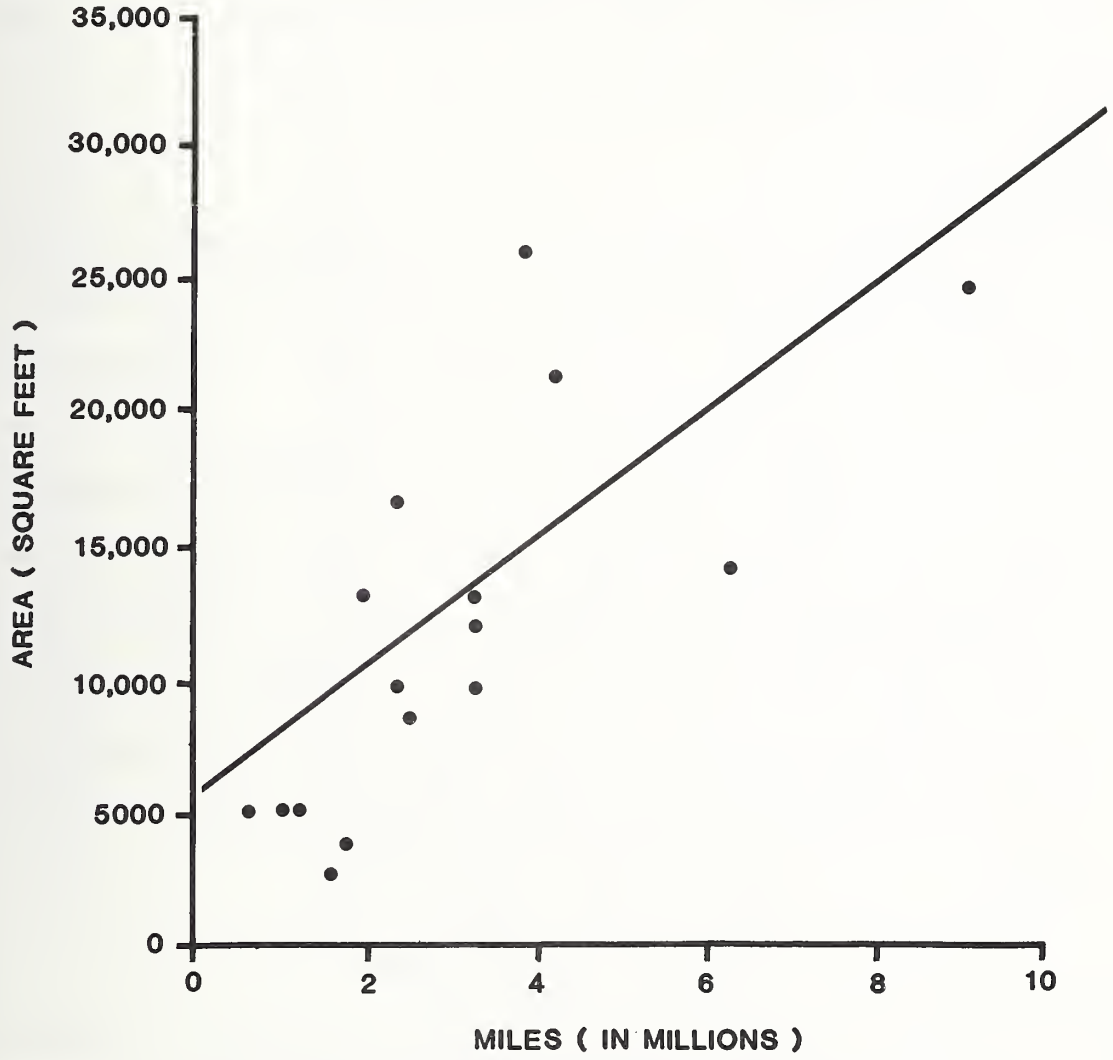
$r^2 = 0.69$ NUMBER OF CASES = 27

x = ANNUAL VEHICLE MILES IN MILLIONS

y = NUMBER OF NON SPECIALIZED MAINTENANCE BAYS

FIGURE V-4

MAINTENANCE BAY AREA VS ANNUAL MILES
SINGLE FACILITY TRANSIT SYSTEM



MAINTENANCE BAY AREA REGRESSION EQUATION:
SINGLE FACILITY SYSTEMS

$y = 246x + 5628$

(62)	(2137)	STANDARD ERROR OF REGRESSION COEFFICIENT
(3.95)	(2.64)	T-VALUE
(0.00)	(0.01)	SIGNIFICANCE OF T-VALUE

$r^2 = 0.53$ NUMBER OF CASES = 16

x = ANNUAL VEHICLE MILES IN 100,000'S

y = TOTAL MAINTENANCE BAY AREA IN SQUARE FEET

using remote systems for dispensing fluids, the system controls and recording meters are typically in this area.

The parts room is usually located near the general repair shop areas in close proximity to the maintenance storage and receiving area. A parts room generally has controlled access. Most of the systems examined used a window at a counter to dispense items from the parts room.

Space Requirements

Lack of parts storage is a problem in some older facilities. Many transit systems are operating a greater variety of vehicles than in the past -- smaller buses, standard buses, and articulated buses. A larger parts inventory must be maintained to accommodate this variety.

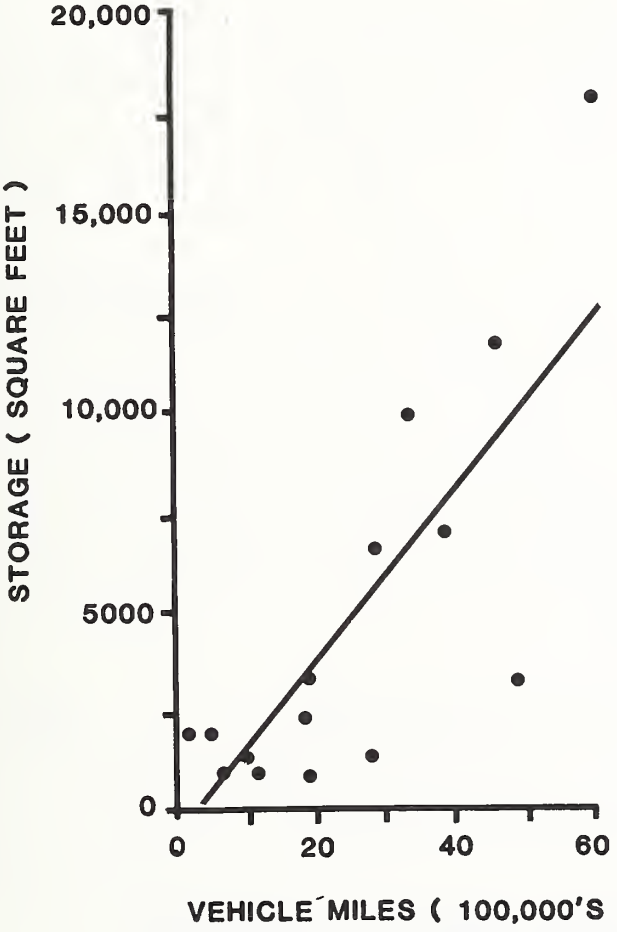
Different parts storage relationships were found for single and multiple facility systems. Over 230 square feet per 100,000 annual vehicle miles are provided in single facility systems (Figure V-5) while a little over half of that amount (126 square feet) is provided in multiple facility systems (Figure V-6). Again this difference may be attributed to the more limited maintenance activities which are typically conducted at operating garages in multiple facility systems.

MAINTENANCE STORAGE

The maintenance storage area provides space for storing large bus components (e.g. body parts and mechanical equipment), maintenance supplies (e.g. drums of grease, oil and solvents) and tools and tool carts. The maintenance storage area is usually located along an outside wall of the building preferably with a loading dock to facilitate delivery of parts, components and supplies. The area is designed to be secure and is located away from heat and flame sources.

FIGURE V-5

PARTS STORAGE SPACE VS ANNUAL VEHICLE MILES
SINGLE FACILITY TRANSIT SYSTEMS



PARTS STORAGE REGRESSION EQUATION:
SINGLE FACILITY SYSTEMS

$y = 233x - 1923$

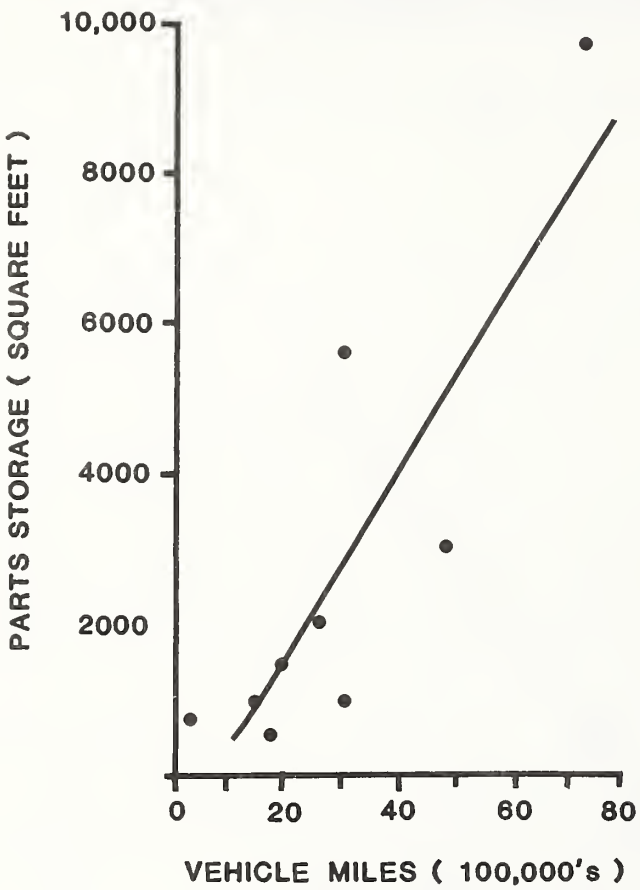
(56)	(1668)	STANDARD ERROR OF REGRESSION COEFFICIENT
(4.18)	(1.15)	T-VALUE
(0.00)	(0.14)	SIGNIFICANCE OF T-VALUE

$r^2 = 0.59$ NUMBER OF CASES = 14

x = ANNUAL VEHICLE MILES IN 100,000'S

y = PARTS STORAGE AREA IN SQUARE FEET

FIGURE V-6
PARTS STORAGE SPACE VS ANNUAL VEHICLE MILES
MULTIPLE FACILITY TRANSIT SYSTEMS



PARTS STORAGE REGRESSION EQUATION:
MULTIPLE FACILITY SYSTEMS

$y = 126x - 821$

(29)	(1010)	STANDARD ERROR OF REGRESSION COEFFICIENT
(4.41)	(0.81)	T-VALUE
(0.00)	(0.22)	SIGNIFICANCE OF T-VALUE
$r^2 = 0.74$		NUMBER OF CASES = 9

x = ANNUAL VEHICLE MILES IN 100,000'S
y = PARTS STORAGE AREA IN SQUARE FEET

Space Requirements

In addition to the parts room, space must be allocated for other storage -- grease, fluids, detergent, body parts, and spare engine and transmission units. A relationship of approximately 50 square feet per 100,000 annual vehicle miles was found for single facility systems (Figure V-7). No significant relationship was identified for multiple facility systems; the variability among these systems in the maintenance activities that they conduct may be an explanation. Table V-3 presents the data and mean values for multiple facility sites.

NON-MILEAGE-RELATED AREAS

The maintenance subareas in this section did not exhibit a strong statistical relationship to any of the expected independent variables. This may be due in part to the fact that maintenance subareas are not always well-defined in a shop, and thus precise measurement of allocated space was not possible.

TIRE SHOP/STORAGE

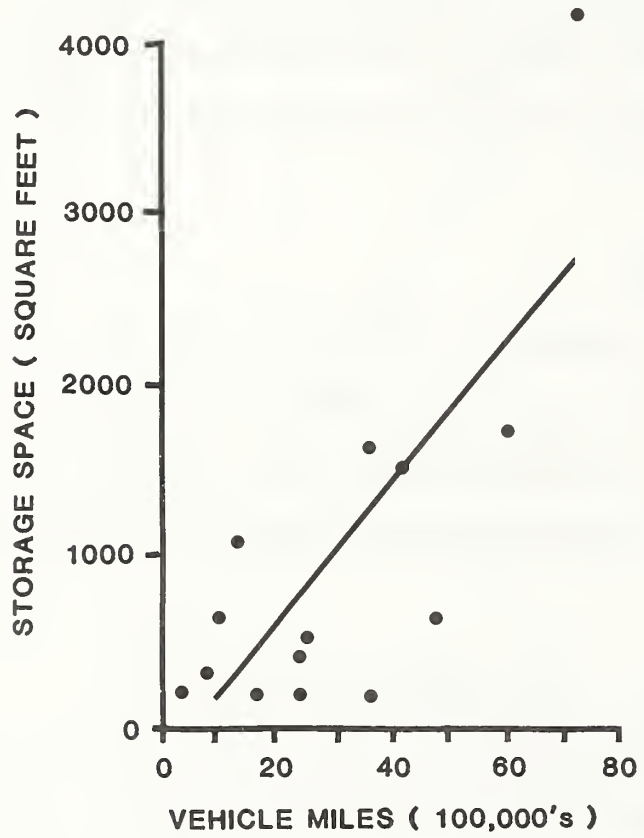
The tire shop/storage area is where bus tires are serviced and stored. If tire regrooving is done on-site then it is conducted in this area. Tire mounting is also completed in the tire shop. The tire shop is usually equipped with a tire mounting/inflation cage which is required by OSHA for the mounting of tires on split-rim wheels. Wheel separators for demounting tires and regrooving machines are also used in this area. Tire racks which allow for storing tires in a vertical position are often used because they allow stored tires to be accessed without having to move other tires.

Almost all systems lease tires rather than purchase them. Some systems have daily tire deliveries, and do very little tire work on site other than

FIGURE V-7

MAINTENANCE STORAGE SPACE VS ANNUAL VEHICLE MILES

SINGLE FACILITY TRANSIT SYSTEMS



MAINTENANCE STORAGE SPACE REGRESSION EQUATION: SINGLE FACILITY SYSTEMS

$y = 52x - 402$

(12) (451) STANDARD ERROR OF REGRESSION COEFFICIENT

(4.10) (0.90) T-VALUE

(0.00) (0.20) SIGNIFICANCE OF T-VALUE

$r^2 = 0.58$ NUMBER OF CASES = 14

x = ANNUAL VEHICLE MILES IN 100,000'S

y = MAINTENANCE STORAGE SPACE IN SQUARE FEET

TABLE V-3

MAINTENANCE STORAGE SPACE
MULTIPLE FACILITY TRANSIT SYSTEMS

Location	Annual Vehicle Miles	Maintenance Storage Space (Square Feet)	Storage Space (Square Feet) Per 100,000 Vehicle Miles
Schenectady, NY	1,490,000	600	40
Troy, NY	1,880,000	406	22
Phoenix, AZ	1,937,504	388	20
Buffalo, NY	2,600,000	648	25
Boulder, CO	3,082,983	96	3
Boston, MA	3,128,721	6,658	213
Rockville, MD	4,836,072	525	11
Aurora, CO	6,755,970	4,686	70
Denver, CO	7,257,000	1,412	19
Mean Value			47
Standard Deviation			65

mounting tires and drums on buses. Other systems only receive new tires and return casings -- performing other maintenance in-house. Among the systems examined, most transit facilities stored two tires per bus in the tire storage area.

Space Requirements

There are two types of tire shop designs. Some systems use a work bay in the general repair area for on-vehicle work, and have a separate area for tire storage and repair. Others enclose the storage area, work area and a bus bay to separate tire work from the rest of the garage. Tire work is dirty and noisy because of air impact wrenches. About half of the facilities that were analyzed chose to separate the tire repair area from the rest of the shop.

As shown in Table V-4, different amounts of space are provided for tire shops in which a bus bay is enclosed and tire shops with no enclosed bays. When no bay is included the mean space provided for a tire shop was about 533 square feet. This number did not appear to be related to any measure of system size or use. For tire shops with enclosed bays there was not the same consistency. While the mean space value was 2,144 square feet, the observed space ranged from 1,043 to 4,160 square feet. Again there did not appear to be any relationship between space provided and system operating characteristics.

OVERHAUL SHOP

The overhaul shop provides work space for rebuilding large bus components. Engine and transmission rebuilding takes place in this area. The area may or may not be enclosed. Large machine tools such as drill presses, hydraulic presses and metal lathes are located in this area. Work benches equipped with small machine tools are also located in the overhaul shop.

TABLE V-4

TIRE SHOP/TIRE STORAGE AREA

Location	Annual Vehicle Miles	Tire Shop/Tire Storage Space (Square Feet)	Space (Sq. Ft.) Per 100,000 Vehicle Miles
Tire Shops Not Including Bus Bay(s)			
Chapel Hill, NC	780,000	491	63
Pensacola, FL	964,000	560	58
Scranton, PA	1,273,343	540	42
Wilmington, DE	2,212,344	486	22
Albuquerque, NM	3,000,000	435	15
El Paso, TX	3,991,826	590	15
Schenectady, NY	1,490,000	600	40
Troy, NY	1,880,000	505	27
Phoenix, AZ	1,937,504	360	19
Boulder, CO	3,082,983	832	27
Rockville, MD	4,836,072	286	6
Louisville, KY	---------	710	--
Mean Value		533	30
Standard Deviation		146	18
Tire Shops Including Bus Bay(s)			
Raleigh, NC	1,476,851	2,436	165
Chattanooga, TN	1,600,000	1,276	80
Duluth, MN	2,083,301	3,221	155
Des Moines, IA	2,100,000	1,128	54
Ft. Wright, KY	3,000,000	2,112	70
Akron, OH	3,465,000	1,043	30
Madison, WI	4,977,696	1,050	21
Omaha, NB	6,000,000	3,389	56
Columbus, OH	8,700,000	1,500	17
Boston, MA	3,128,721	4,160	133
Denver, CO	7,257,000	2,240	31
Mean Value		2,144	74
Standard Deviation		1,129	54

Space Requirements

Not all of the transit systems that were analyzed had special overhaul shops. There were no overhaul shops at operating garages in multiple facility systems since component rebuilding generally takes place at main maintenance facilities in these systems. The five smaller single facility systems also had no overhaul shops. This may suggest that the volume of rebuild work generated by a small fleet does not warrant a specially designated area. No facility operating less than 1.6 million vehicle miles of service was observed to have a special overhaul shop.

For facilities that include an overhaul shop Table V-5 shows annual vehicle miles operated, size of overhaul shop and space in the shop per 100,000 vehicle miles. No statistically significant relationship could be identified between independent variables and space allocation for this function. Table V-5 shows that the mean size is 63 square feet per 100,000 vehicle miles, with a standard deviation of 40 square feet.

BRAKE REPAIR SHOP

The brake repair area is a work shop for the servicing and repair of brake system components. Brake relining and drum turning are the primary activities carried out in this area. Brake lathes for turning drums and sizing linings are located within this area.

The brake repair area is usually located adjacent to repair bays to minimize the need for moving tires and drums between the buses and the shop. The shop area typically has a jib crane for lifting tires and drums off dollies onto a brake lathe. The shop may or may not be enclosed. Special exhaust systems on brake lathes to evacuate hazardous brake lining dust are required by OSHA regulations.

TABLE V-5

OVERHAUL SHOPS
SINGLE FACILITY TRANSIT SYSTEMS

Location	Annual Vehicle Miles	Size of Overhaul Shop (Square Feet)	Overhaul Space (Square Feet) Per 100,000 Vehicle Miles
Chattanooga, TN	1,600,000	700	42
Duluth, MN	2,083,301	3,038	146
Des Moines, IA	2,100,000	525	25
Wilmington, DE	2,212,344	2,000	90
Albuquerque, NM	3,000,000	163	5
Fort Wright, KY	3,000,000	3,538	118
Jacksonville, FL	3,000,000	945	32
Akron, OH	3,465,888	2,382	69
El Paso, TX	3,991,826	1,940	49
Madison, WI	4,977,696	3,000	60
Omaha, NB	6,000,000	2,560	43
Columbus, OH	8,700,000	7,100	82
Mean Value		2,324	63
Standard Deviation		1,858	40

Space Requirements

Six of the single facility properties examined had separate, enclosed space allocated for a brake repair shop. In other cases brake repair is conducted at work areas within the general repair area and the precise square foot allocation could not be determined. None of the facilities operated by multiple facility systems formally allocated space for brake repair. At the larger systems, brake relining and drum turning was often conducted at a main maintenance facility.

Table V-6 shows the data available on brake shops. The data set is too small to determine a relationship between space allocation and independent variables.

BODY SHOP

The body shop is used in the repair or replacement of such items as windows, doors, body panels, seats, floor mats and body trim. At some locations body shops are simply work areas within the maintenance bay area. In others, body bays are separated from general repair bays by a partition. The body shop is generally located adjacent to the paint shop, because body and paint work are closely associated and very often the same personnel are responsible for conducting both functions.

Space Requirements

All but one of the facilities allocating space for the body shop were operated by single facility systems. Multiple facility systems generally conduct body work at main maintenance facilities.

No statistical relationship could be found between body shop space and annual vehicles miles operated. This is probably due to policy differences among the sites regarding contracting of body work. Table V-7 shows the data, mean values and standard deviations.

TABLE V-6

BRAKE SHOPS

Location	Annual Vehicle Miles	Size of Brake Shop (Square Feet)	Space (Sq. Ft.) Per 100,000 Vehicle Miles
Brake Shops Not Including Bus Bay(s)			
Pensacola, FL	964,000	140	15
Scranton, PA	1,273,343	242	19
Omaha, NB	6,000,000	608	10
Mean Value		330	15
Standard Deviation		246	5
Brake Shops Including Bus Bay(s)			
Duluth, MN	2,038,301	1,400	67
Jacksonville, FL	3,000,000	2,300	77
Columbus, OH	8,700,000	1,250	14
Mean Value		1,600	53
Standard Deviation		568	34

TABLE V-7

BODY AND PAINT SHOP

Location	Annual Vehicle Miles	Body Shop (Sq. Feet)	Body Shop Space Per 100,000 Vehicle Miles	Paint Shop (Sq. Feet)	Paint Shop Space Per 100,000 Vehicle Miles
Galveston, TX	435,676	1,102	253	——	——
Pensacola, FL	964,000	1,134	118	——	——
Raleigh, NC	1,476,851	1,625	110	——	——
Chattanooga, TN	1,600,000	4,000	250	810	51
Duluth, MN	2,083,301	4,200	202	2,304	110
Des Moines, IA	2,100,000	2,408	115	1,248	59
Wilmington, DE	2,212,344	1,210	55	950	43
Albuquerque, NM	3,000,000	1,200	40	1,260	42
Fort Wright, KY	3,000,000	264	8	1,173	39
Jacksonville, FL	3,000,000	6,534	218	3,700	123
Akron, OH	3,465,888	921	27	999	29
El Paso, TX	3,991,826	2,809	70	2,277	57
Madison, WI	4,977,696	600	12	1,300	26
Omaha, NB	6,000,000	2,515	42	2,852	48
Columbus, OH	8,700,000	9,550	110	5,575	64
Denver, CO [1/]	7,257,000	5,280	72	——	——
Mean Value		2,834	106	2,037	58
Standard Deviation		2,532	82	1,425	30

1. Multiple facility system.

PAINT SHOP

Since the paint shop is usually adjacent to the body shop, other body work may be conducted on vehicles while they are in the painting bay. The personnel working in the painting bay usually have responsibility for a wide range of body repair tasks.

Body painting is usually done with hand-held compressed-air sprayers. Platforms placed around the vehicle are often used to provide easy access for painting the upper portions of vehicles. A drop table in the painting area, which lowers and raises the vehicle as needed, is used at some sites to provide easier access to buses. Some systems have elected to install travelling paint booths. These devices travel on rails over the length of the bus allowing painters to apply a uniform coat of paint.

Paint booths are completely enclosed to contain paint dust and fumes. Each booth is equipped with its own ventilating and exhaust equipment. Exhaust air is usually filtered through a waterfall to remove dust and paint. Most properties have prefabricated paint booths that are installed on site.

Space Requirements

Twelve maintenance facilities in the data set formally allocated space for a paint shop. All of the facilities were operated by single facility systems. Normally, multiple facility systems conduct vehicle painting at main maintenance facilities along with body work.

No statistical relationship could be identified between likely independent variables and the amount of space allocated to painting. Table V-7 shows the raw data and space allocation per 100,000 annual vehicle miles.

The source of variation in square feet allocated to vehicle painting appears to be the space allocated for vehicle preparation and finishing. A number of systems have a bay available in line with the paint booth for

masking the bus. Sometimes another bay is used for touch-up and final preparation for returning the vehicle to service. Thus a facility with only one paint booth could have three bays devoted to painting.

STEAM CLEANING

In order to effectively repair and inspect buses, most properties degrease components first. Bus engines, radiators, compressors, and other components in the engine compartment are cleaned of grease, oil and road dirt prior to maintenance.

Steam cleaning is done in almost all facilities. However, not all facilities were observed to have special steam clean bays. Those without special bays use portable equipment to degrease engines in the general wash area. One small garage simply degreases outside on the pavement. Steam cleaning bays are generally enclosed and equipped with a wheel hoist to facilitate cleaning of the undercarriage. The drainage system should include a grease separator for environmental reasons.

Space Requirements

Regardless of size, no facility was observed with more than one steam cleaning area. Areas allocated for steam cleaning that are less than 500 square feet are not full bus bays. These areas are used for cleaning only the rear of a bus or are open areas designated for steam cleaning. Larger areas represent full bays

The range of space allocated was 220 to 1,950 square feet with a mean value of 1,160 square feet, as shown in Table V-8.

BATTERY STORAGE ROOM

The battery storage room provides space for safe storage and maintenance of spare batteries. Batteries are usually kept in a completely enclosed room

TABLE V-8

SPACE ALLOCATED FOR STEAM CLEANING

Fleet Size	Location	Size of Steam Clean Area (Square Feet)
29	Pensacola, FL	220 [1/]
44	Schenectady, NY	900
58	Raleigh, NC	1,476
69	Chattanooga, TN	1,950
93	Phoenix, AZ	1,600
95	Duluth, MN	1,400
96	Ft. Wright, KY	672 [1/]
106	Boulder, CO	1,152 [1/]
120	Buffalo, NY	1,120
129	Akron, OH	440 [1/]
145	Boston, MA	1,152
147	Rockville, MD	1,476
150	El Paso, TX	1,060
197	Omaha, NB	945
208	Aurora, CO	1,400
211	Louisville, KY	1,386
233	Denver, CO	1,200
267	Jacksonville, FL	1,000
322	Columbus, OH	1,500
Mean		1,160
Standard Deviation		414

1. Areas less than 800 square feet are not full bus bays. Some locations allocate only enough space to clean the rear portion of buses.

convenient to bus parking and repair areas. The walls and floor are generally acid resistent, and the door big enough to admit battery transporting equipment. A separate door for personnel is often provided.

Space Requirements

Battery storage rooms were observed in almost all of the facilities examined. At facilities without space allotted for a battery storage room, batteries are simply stored in a parts or component storage area. Among the facilities observed the range of space allocated for the battery storage room was 80 to 720 square feet with a mean of 245 square feet.

DYNAMOMETER BAY

The dynamometer bay is a bus bay for performance testing. In a chassis dynamometer, the rear bus wheels sit on rollers to allow the engine and drive train to be tested at various engine RPM levels. The dynamometer bay is usually located adjacent to the repair bays to permit buses to be tested before and after mechanical repairs are made.

The area is usually equipped with diagnostic equipment necessary to analyze vehicle performance. The dynamometer is located in the middle of the bay with wide clearances (8 to 10 feet) on all sides. In some systems brake testing equipment was also located within the bay.

An acoustically treated enclosure is required because of the noise generated by a bus operating indoors a full power. The area must have an independent ventilating system to exhaust fumes that build up during testing.

Space Requirements

Four facilities at single facility transit systems were observed with space allocated for a dynamometer bay. None of the observed operating garages at multiple facility systems had space allocated for a dynamometer bay since

the main maintenance facilities often provided space for a dynamometer bay. No case was observed where more than one dynamometer bay was necessary.

The smallest observed bay was approximately 20 x 60 feet -- 1,200 square feet. The largest was 2,200 square feet and the average was approximately 1,700 square feet.

PARTS CLEANING

The parts cleaning area is where parts are cleaned for servicing and reuse. The area is usually equipped with dip tanks for chemical cleaning. Some properties also use sand blasting on some vehicle parts. The parts cleaning area is generally enclosed and located away from heat or flame sources, floors and walls are impervious to solvents, and the area is well ventilated.

Space Requirements

Six of the single-facility properties examined had space allocated for parts cleaning. The observed values range from 169 to 825 square feet. The mean observed value was 500 square feet for the parts cleaning area. All properties do parts cleaning, of course, but not all have included a separate room for parts cleaning. There were no operating garages observed at multiple facility systems with space formally allocated for parts cleaning.

INJECTOR REPAIR AREA

An injector repair area is where diesel fuel injectors are cleaned and serviced. This area is enclosed and well ventilated to control dust.

Space Requirements

Five of the single facility properties provided space for injector repair. The area allocated ranged from 104 square feet to 423 square feet

with a mean value of 187 square feet. Multiple facility systems generally conduct injector repair at a main maintenance facility.

It is very common for systems to contract injector repairs rather than do it in-house. This accounts for the relatively small number of injector rooms among the observed systems.

ELECTRICAL SHOP

The electrical shop is a work area for the repair and overhaul of electric components. The area is equipped with testing equipment, work benches, vices and small machine tools such as grinders and drills.

Space Requirements

Four single facility properties were observed with designated electric shops. The observed range of space allocated for this function was from 140 to 510 square feet of space with a mean value of 291 square feet. Other properties perform electrical repairs in general repair areas rather than in separate shops.

WELDING SHOP

A welding shop is equipped with work benches, vices and welding tools. The area is usually enclosed. Welding areas are well ventilated with welding hoods located over the work area. The Occupational Safety and Health Administration has set standards which must be examined when planning for this work area.

Space Requirements

Five single facility properties were observed with welding shops. The observed size of this area ranged from 140 to 990 square feet. The observed mean value was 411 square feet allocated for the welding shop. The most common size for welding shops is about 250 square feet.

MAINTENANCE OFFICES

Maintenance office areas include space for the foreman's office, clerks offices and secretarial support. Daily maintenance activities are directed and controlled from this area and maintenance records are maintained here. The space allocated for maintenance offices was analyzed in terms of the personnel utilizing the space.

As shown in Figure V-8, approximately 184 square feet of maintenance office space plus 8.37 square feet per mechanic was provided. The relationship is not strong; the coefficient of determination (r^2) is only 0.38. However, the relationship does reflect the practice of providing a minimum of one foreman's office plus additional office space for supervisory personnel as the mechanical staff becomes larger.

MECHANICS' LOCKER ROOM

The mechanics' locker room provides space for lockers and dressing areas. In some cases the locker room may include restroom facilities and showers.

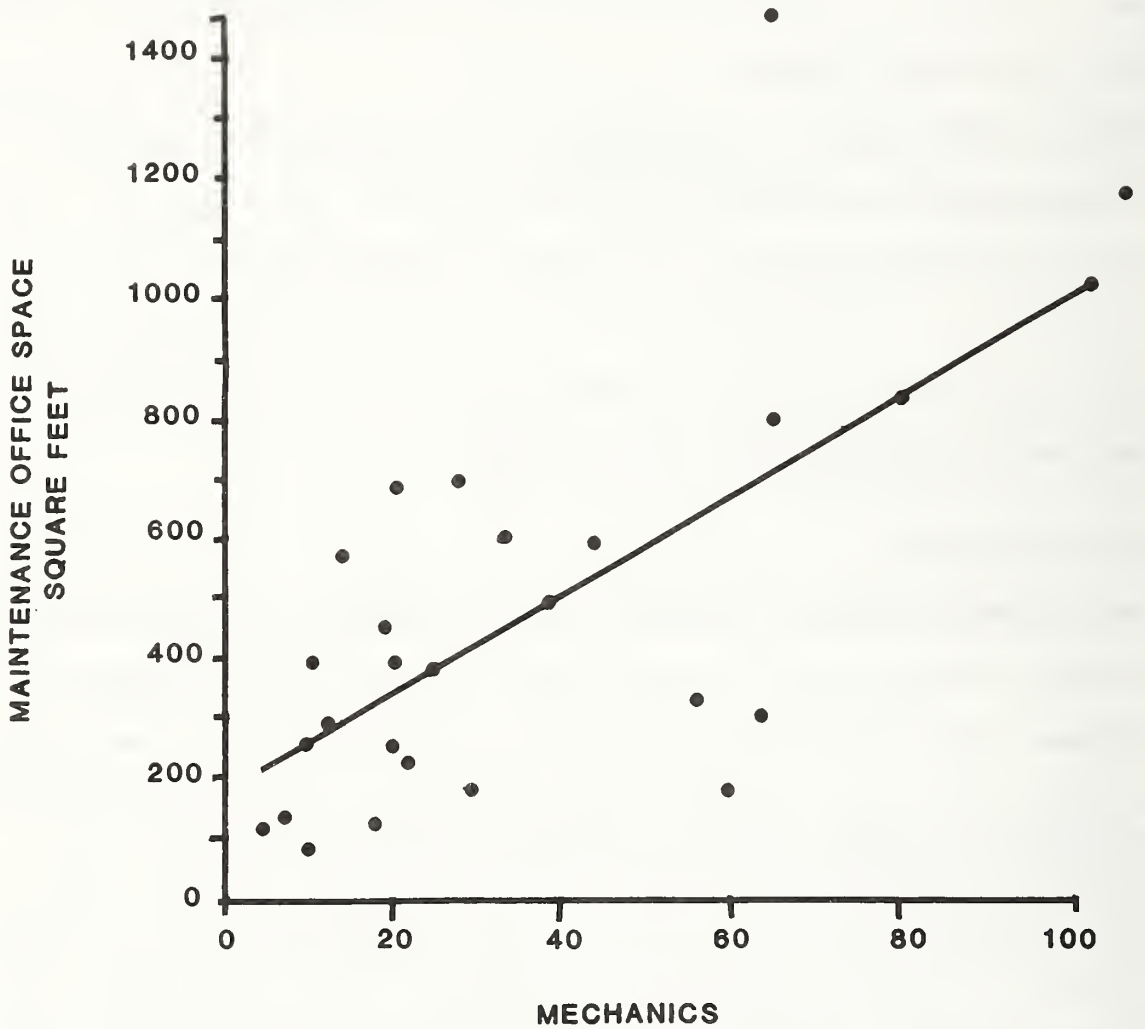
Eighteen of the observed facilities had space allocated for a mechanics' locker room. The space allocated ranged from 9 to 268 square feet per mechanic with a mean value of 55 square feet per mechanic. The wide range of allocated space appeared to be the result of locker room design. Some systems have elected to provide only space for lockers in this area while other systems have included showers, restrooms, wash-up and dressing areas within the mechanics' locker room. Table V-9 illustrates space allocated for mechanics' lockers as well as lunch room and general support areas.

MECHANICS' LUNCH ROOM

The mechanics' lunch room provides space for tables and chairs where mechanics take their lunch breaks. This area may provide space for vending

FIGURE V-8

MAINTENANCE OFFICE SPACE VS. MECHANICS



MAINTENANCE OFFICES REGRESSION EQUATION

$y = 8.37x + 184$

(2.27) (273) STANDARD ERROR OF REGRESSION COEFFICIENT

(3.67) (0.67) T-VALUE

(0.00) (0.52) SIGNIFICANCE OF T-VALUE

$r^2 = 0.38$ NUMBER OF CASES = 24

x = NUMBER OF MECHANICS EMPLOYED

y = MAINTENANCE OFFICE SPACE IN SQUARE FEET

TABLE V-9

PERSONNEL-RELATED MAINTENANCE AREAS

		Space In Square Feet				
Site	Fleet	Mechanics	Employee Support	Maint. Offices	Maint. Lunch	Maint. Lockers
Longmont	12	6	352	0	240	0
Schenectedy	44	64	260	300	0	240
Troy	67	27	163	158	0	309
Phoenix	93	60	0	182	760	1,250
Boulder	106	20	128	248	0	396
Buffalo	120	10	0	400	0	0
Boston	145	57	2,404	310	0	1,032
Rockville	147	27	2,792	720	912	0
Aurora	208	20	1,200	685	0	763
Platte	233	105	448	1,168	672	0
Akron	129	21	0	458	930	1,587
Albuquerque	107	20	380	380	0	160
Chapel Hill	48	6	0	140	124	0
Chattanooga	69	18	0	0	0	0
Columbus	322	64	0	800	0	0
Des Moines	100	18	0	0	0	2,880
Duluth	95	22	0	384	368	896
El Paso	150	43	320	598	1,633	1,377
Ft. Wright	96	15	900	569	0	1,181
Galveston	15	4	737	143	0	128
Jacksonville	267	48	0	570	1,225	916
Madison	187	35	1,020	570	0	0
Omaha	197	65	1,156	1,499	966	1,943
Pensacola	29	18	189	144	236	0
Raleigh	58	8	0	96	260	0
Scranton	36	11	260	300	0	240
Wilmington	100	21	135	220	0	450

machines or may include a kitchenette for preparing hot foods. The lunch room may also serve as a conference room for the maintenance department for group meetings.

Thirteen facilities were observed with space allocated for the mechanics' lunch room. The observed space ranged from 6 to 109 square feet per mechanic with a mean value of 33 square feet per mechanic. The wide range of space allocated appeared to be related to whether or not kitchen facilities were provided within the lunch room area.

EMPLOYEE SUPPORT AREAS

Employee support areas include restrooms, non-lunch room vending areas, and washing and shower areas if separate from locker rooms. Space was allocated for maintenance employee support areas at 18 of the observed facilities. The space allocated ranged from 5 to 139 square feet per mechanic with a mean value of 39 square feet per mechanic.

VI. BUS CIRCULATION, STORAGE, SERVICING AND INSPECTION

Among most, if not all, bus maintenance and storage facilities there are areas provided for the following functions:

- o Circulation
- o Bus Storage
- o Vehicle Servicing
- o Vehicle Inspection

Good circulation within the facility site is important to efficient operation. Bus storage, whether indoor or outdoor, must provide a secure and safe place to store buses. Vehicle servicing includes vaulting (removal of money from fareboxes), fueling, cleaning and washing of in-service buses. Vehicle inspection is part of preventative maintenance. If mechanical problems can be diagnosed before actual failure, repair work can be scheduled in an orderly fashion rather than on an emergency basis. Space allocation guidelines and layout consideration are discussed in this chapter.

CIRCULATION

A well-laid-out bus maintenance and storage facility lends itself to the efficient operation of the functions to be carried out. The layout and site plan encourage a well organized work flow and ease of circulation for vehicles. The circulation plan for bus facilities is planned with three elements in mind. These elements are:

- o Building Plan
- o Traffic Flow
- o Vehicle Parking

Building Plan

The maintenance facilities observed during this research are of three basic types:

- o Internal Circulation
- o Pull-in, Pull-out
- o Drive Through

Each design has advantages and disadvantages. The decision to build a certain type is a function partly of climate and partly of the preference of a particular property based on past experience. Some facilities combine drive-through design and pull-in, pull-out design to achieve greater flexibility. Table VI-1 lists the facilities of each type that were reviewed in this project and the page reference of the floor plan in Appendix A. Each design type is represented in about the same proportion in the data set.

Figure VI-1 illustrates a facility with internal circulation access to maintenance bays. This design is most appropriate in cold climates, because few doors are required for access to the repair area. The design shown in Figure VI-1 can be expanded by utilizing two rows of maintenance bays with a center aisle.

The pull-in, pull-out design is illustrated in Figure VI-2 by the Chattanooga facility. This design is most efficient in mild climates where the doors can be opened for ventilation most of the year, but it is found in all climates. This design provides natural lighting at the exterior end of the bay when doors are open. Whether the buses are headed in or backed in is a matter of preference by the maintenance director.

Figure VI-3 illustrates a facility in Wilmington, Delaware, that can be operated as a drive-through or pull-in, pull-out facility. The essential feature of this design is that the building has doors on both sides and a

TABLE VI-1

BASIC FACILITY DESIGN PLANS

Internal Circulation		Pull-In, Pull-Out		Drive-Through	
Akron	A-9	Chattanooga	A-23	Albuquerque	A-14
Columbus	A-27	Pensacola	A-67	Chapel Hill	A-19
Duluth	A-35	Raleigh	A-71	Des Moines	A-31
Madison	A-59	Schenectady	A-85	El Paso	A-39
Omaha	A-63	Troy	A-89	Ft. Wright	A-43
Albany-Watervliet	A-93	Atlanta-Browns Mill	A-95	Galveston	A-47
Boston-South Bay	A-99	Denver-Platt	A-107	Jacksonville	A-51
Denver-Aurora	A-111	Denver-Boulder	A-115	Louisville	A-55
St. Paul	A-135	Phoenix-North	A-123	Scranton	A-75
		Phoenix-South	A-127	Wilmington	A-79
		Seattle	A-131	Buffalo-New Frontier	A-103
		Washington, DC Nicholson Lane	A-139	Denver-Longmont	A-119

Note: Page numbers refer to the location in Appendix A of floor plan sketches for each facility.

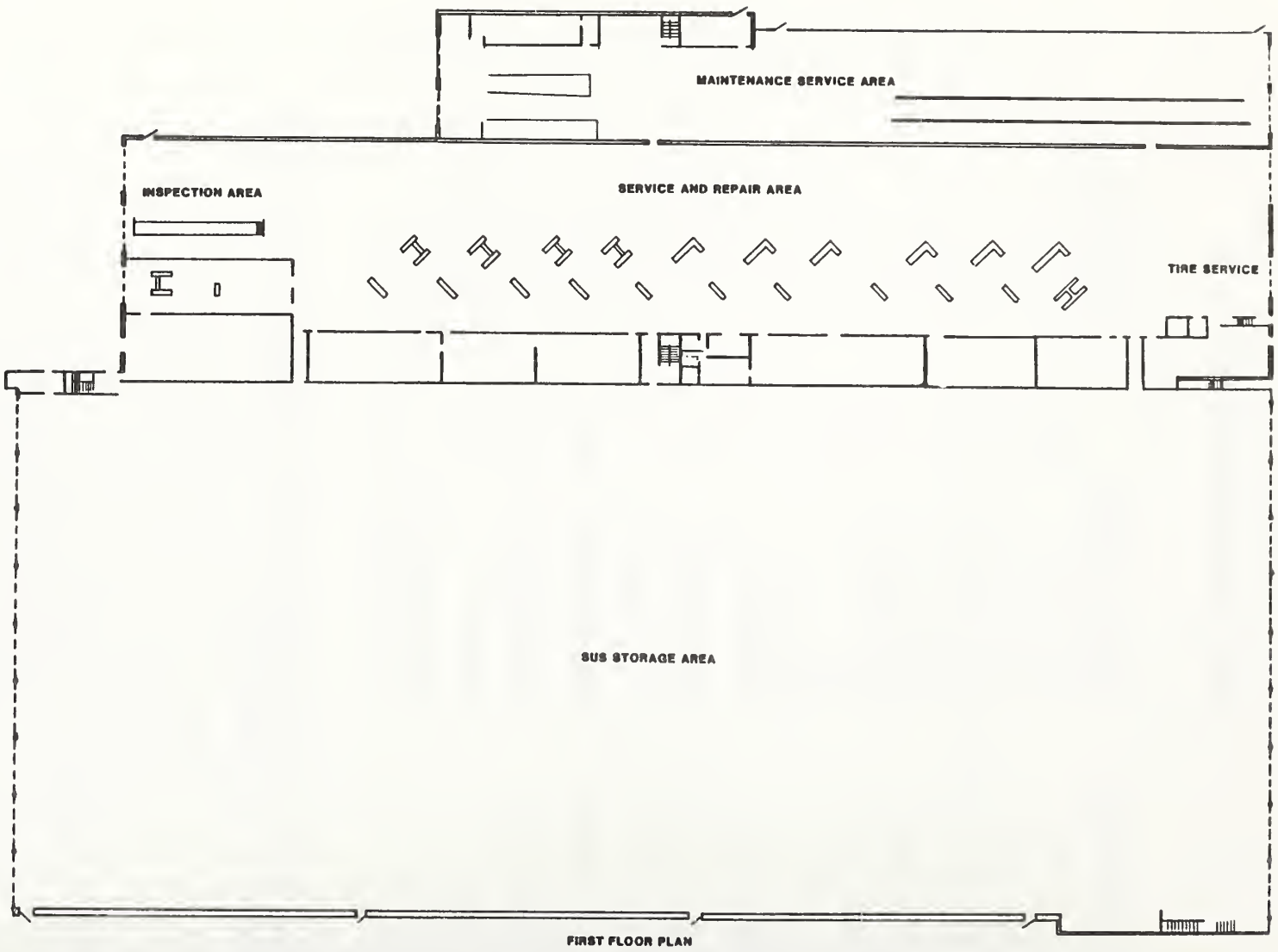
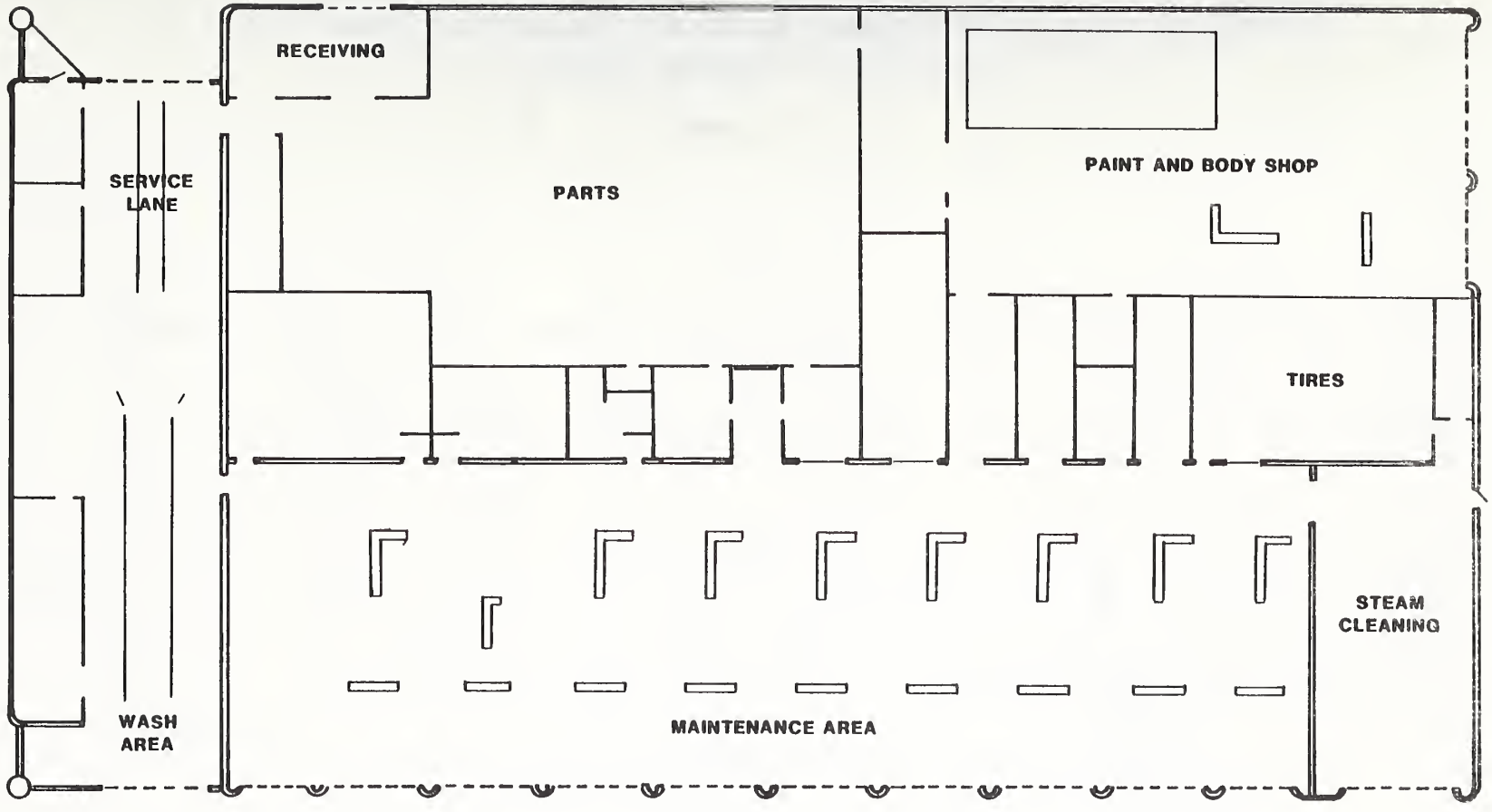


FIGURE VI-1

INTERNAL CIRCULATION FLOOR PLAN
CABOT GARAGE / MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
BOSTON, MASSACHUSETTS



MASTER FLOOR PLAN

FIGURE V-2

PULL-IN/PULL OUT FLOOR PLAN
BUS MAINTENANCE FACILITY / CHATTANOOGA AREA TRANSIT AUTHORITY
CHATTANOOGA, TENNESEE

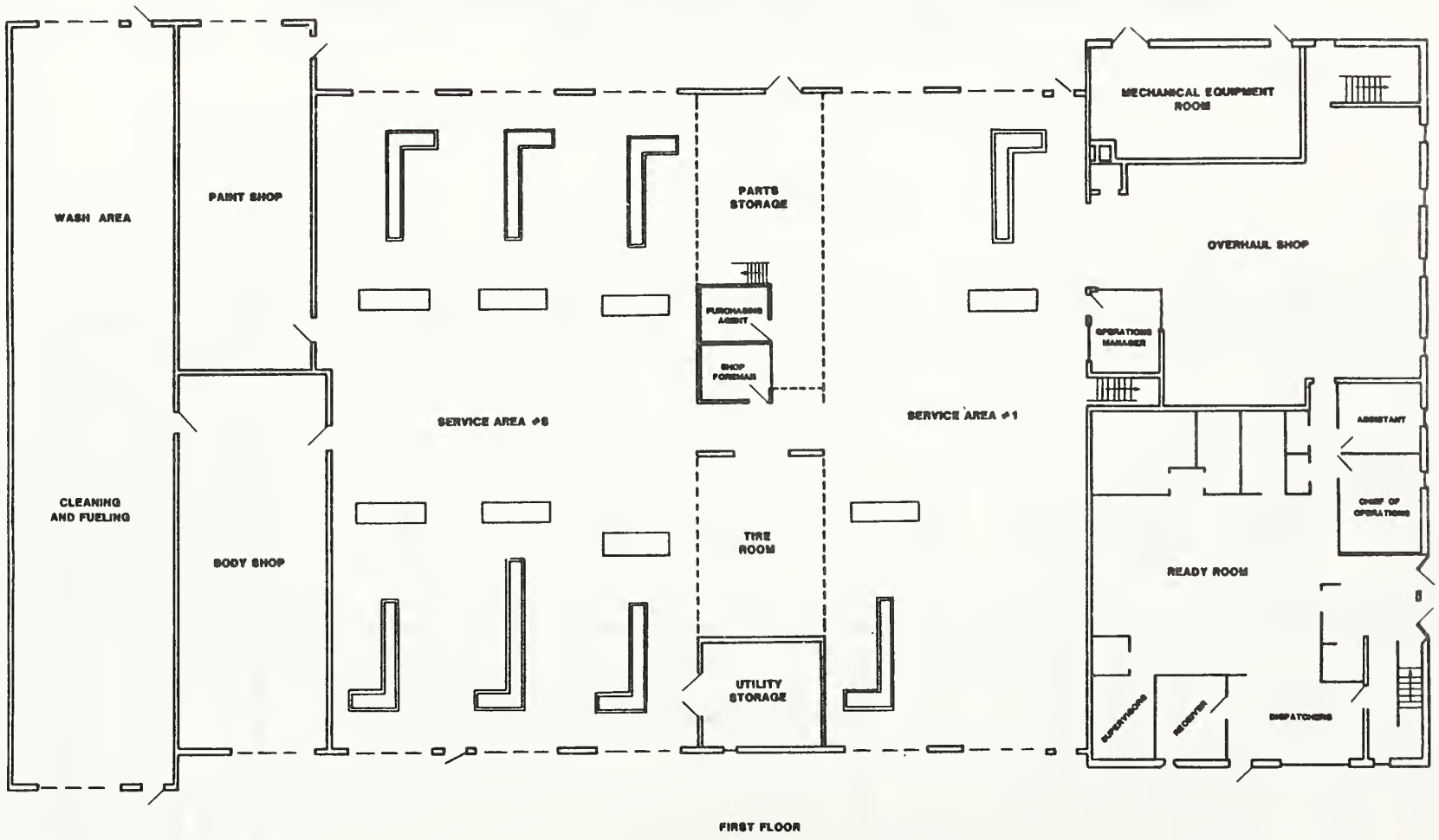


FIGURE VI-3

DRIVE THROUGH FLOOR PLAN

DART OPERATIONS CENTER / DELAWARE ADMINISTRATION FOR RAPID TRANSIT

WILMINGTON, DELAWARE

clear lane through the building. A double bay arrangement can be utilized as shown in Figure VI-3 or a single bay arrangement.

Traffic Flow

Figure VI-4 shows a typical bus circulation plan. This basic operating plan was followed by most of the sites for which data were assembled in this study. Buses follow a left-hand circulation pattern, whenever possible. Left-hand turns allow bus operators maximum visibility for judging rear wheel clearance. Figure VI-5 illustrates the clearances required by a forty foot bus executing turning movements.

Vehicle Parking

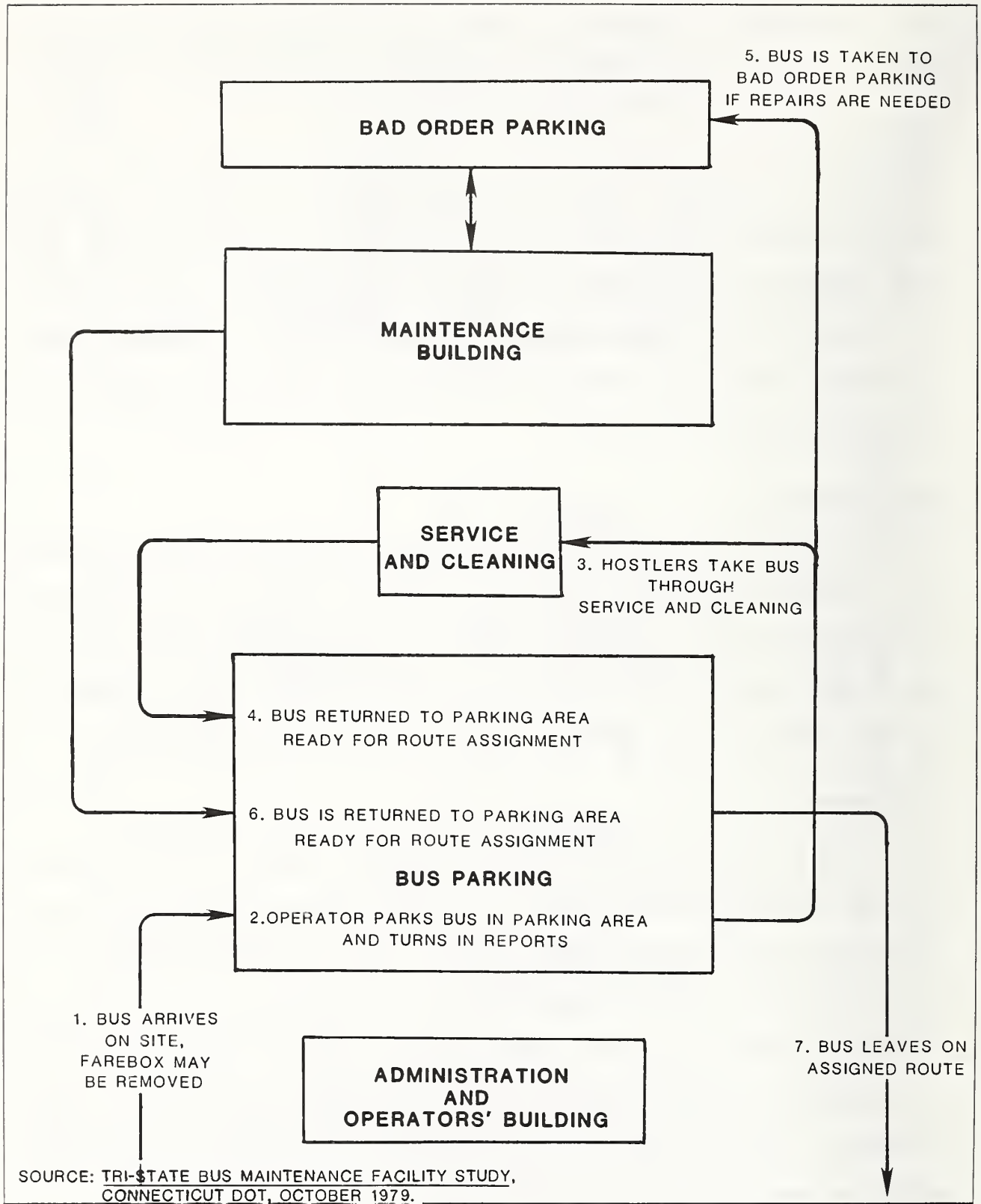
All transit facilities require space for parking vehicles other than buses. Parking for employees, utility and service vehicles and visitors was provided at most sites visited. These parking areas were generally apart from bus storage areas and regular bus circulation lanes. Open lot parking requires about 300 square feet per vehicle, including circulation areas.

BUS STORAGE

One of the principle functions of any operating garage is bus storage. Efficient bus parking configurations on a garage site are essential for smooth operations within the site. Six different types of parking configurations were encountered as shown in Figure VI-6.

Data on outdoor bus parking space were not assembled during this research effort, because adequate guidelines for outdoor parking have been established previously. Table VI-2 shows the space required to park vehicles in different parking patterns as developed by others.

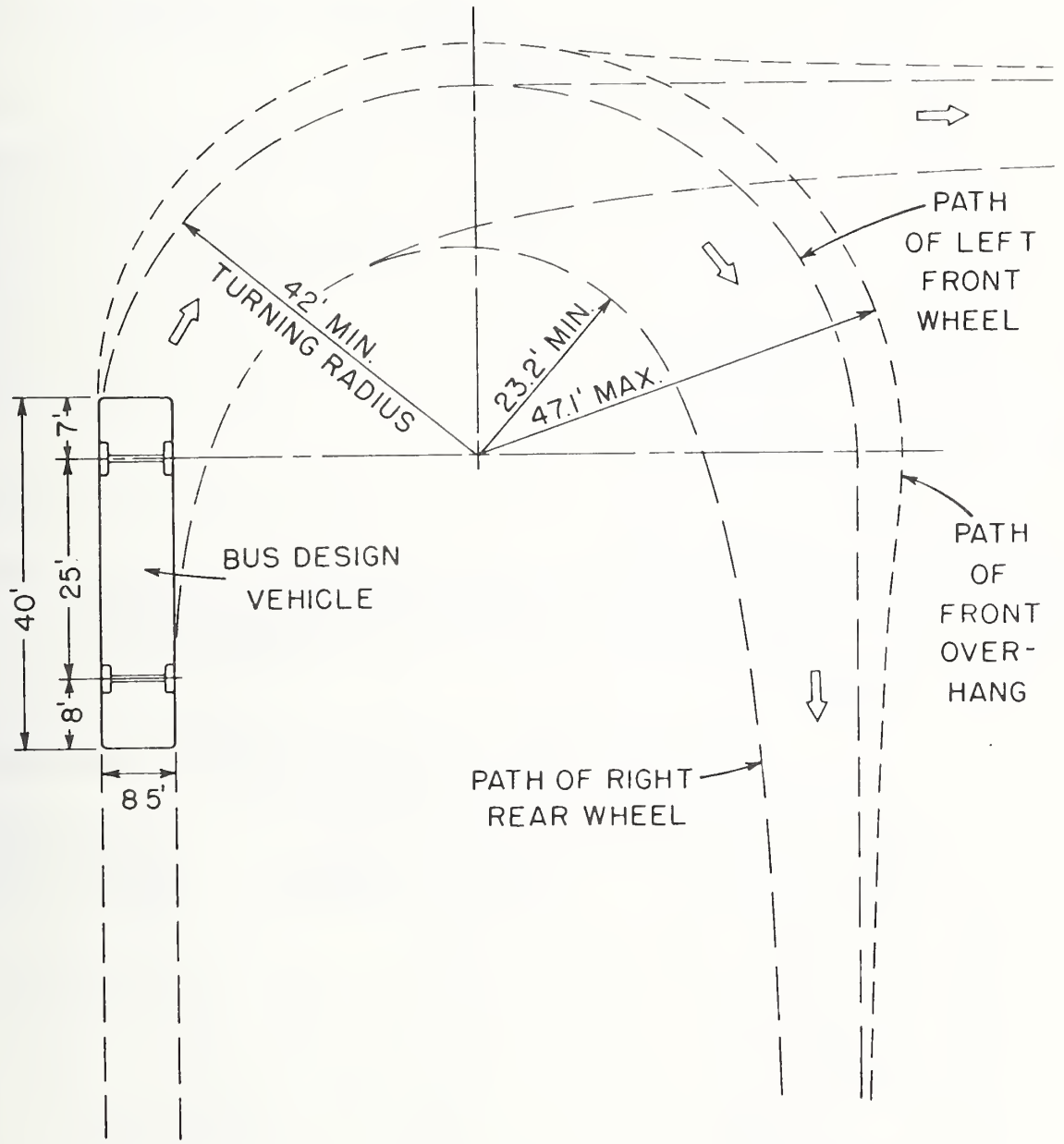
The choice of parking pattern for a particular application is influenced by site and circulation constraints. Table VI-3 shows the outdoor parking


5. BUS IS TAKEN TO BAD ORDER PARKING IF REPAIRS ARE NEEDED
BAD ORDER PARKING
MAINTENANCE BUILDING
SERVICE AND CLEANING
3. HOSTLERS TAKE BUS THROUGH SERVICE AND CLEANING
4. BUS RETURNED TO PARKING AREA READY FOR ROUTE ASSIGNMENT
6. BUS IS RETURNED TO PARKING AREA READY FOR ROUTE ASSIGNMENT
BUS PARKING
2.OPERATOR PARKS BUS IN PARKING AREA AND TURNS IN REPORTS
1. BUS ARRIVES ON SITE, FAREBOX MAY BE REMOVED
ADMINISTRATION AND OPERATORS' BUILDING
7. BUS LEAVES ON ASSIGNED ROUTE

SOURCE: TRI-STATE BUS MAINTENANCE FACILITY STUDY, CONNECTICUT DOT, OCTOBER 1979.

FIGURE VI-4

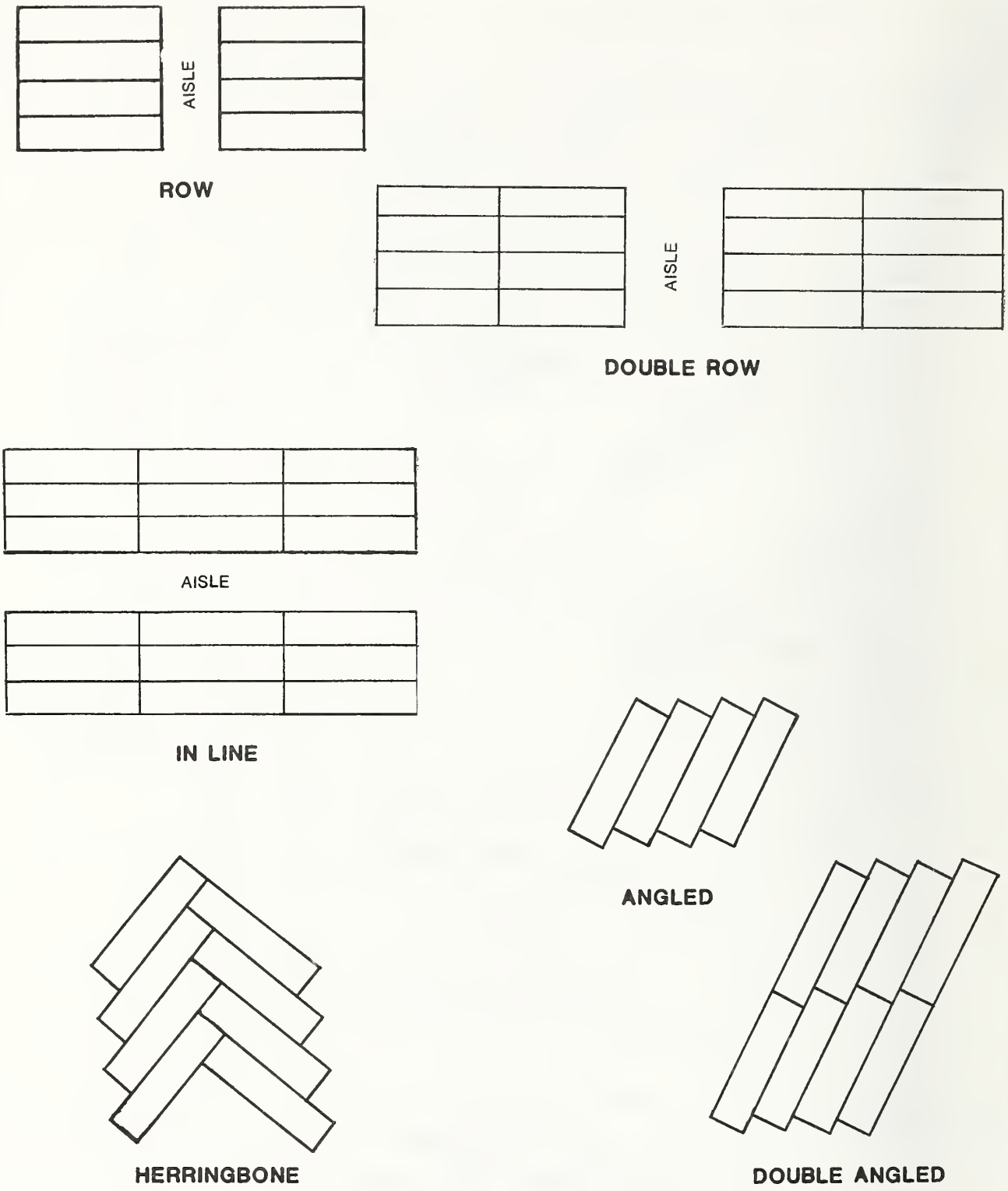
TYPICAL BUS CIRCULATION PLAN



SOURCE: BUS STORAGE, MAINTENANCE, OPERATING AND GENERAL OFFICE FACILITIES, CITY OF HOUSTON, TEXAS, JUNE 1975.

FIGURE VI-5

MINIMUM TURNING PATH FOR BUS DESIGN VEHICLE



SOURCE: BUS MAINTENANCE FACILITIES: A TRANSIT MANAGEMENT HANDBOOK, USDOT, NOVEMBER 1975.

FIGURE VI-6
PARKING CONFIGURATIONS

TABLE VI-2

BUS PARKING SPACE REQUIREMENTS

HOUTRAN BUS PARKING SPACE REQUIREMENTS

	Square Feet Per Bus	Total Square Feet	Acres
Conventional Stacked Parking	504	126,000	2.89
Single 30 Drive-Thru Bay	1,449	362,250	8.32
Double 30 Drive-Thru Bay	920	230,000	5.28
Single 45 Drive-Thru Bay	1,464	366,000	8.40
Single 60 Drive-Thru Bay	1,326	331,500	7.61

* Based on 250 vehicle facility

SOURCE: Prototypical Design Criteria For A Satellite Bus Maintenance Facility, prepared for Metropolitan Transit Authority of Harris County, Texas, by Fleet Maintenance Consultants, Inc., April 1980.

CHICAGO TRANSIT AUTHORITY BUS PARKING SPACE REQUIREMENTS

Criteria Capacity (Number of Buses)	Areas Required for Parking (Square Feet)	
	In-Line Pattern	Chevron Pattern
100	94,260	138,320
150	129,330	197,680
200	160,240	257,040
250	195,550	316,400
300	230,800	375,760
350	274,460	435,120

SOURCE: Bus Garage Standardization and Rehabilitation for the Chicago Transit Authority, prepared by DeLeuw Cather & Company, August 1977.

TABLE VI-3

OUTDOOR BUS STORAGE SPACE

Location	Number of Parking Bays	Parking Configuration
Galveston, TX	16	Inline
Seattle, WA	20	Inline
Chapel Hill, NC	32	Angled
Albuquerque, NM	33	Inline
Pensacola, FL	40	Herringbone
Raleigh, NC	54	Inline
Phoenix, AZ -- NO.	187	Double Angled
Wilmington, DE	150	Inline
Phoenix, AZ -- SO.	200	Double Angled
Rockville, MD	225	Double Angled
El Paso, TX	255	Inline
Jacksonville, FL	302	Angled/Row

types used by properties in the data set. Conventional stacked parking is only selected for outdoor parking when the site is small. If possible, modern facilities are constructed on sites large enough to permit a parking pattern that allows access to every vehicle at all times. Direct access greatly simplifies maintenance access, pull-outs and pull-ins. Figure VI-7 and VI-8 show layouts with critical dimensions for several angle parking patterns.

Among properties located in harsher climates the trend has been toward indoor bus storage, because managers believe it reduces maintenance and extends vehicle life. Indoor bus storage was found in locations where the temperature drops below 32 degrees Farenheit more than one hundred nights per year. The in-line row configuration is usually used to conserve space.

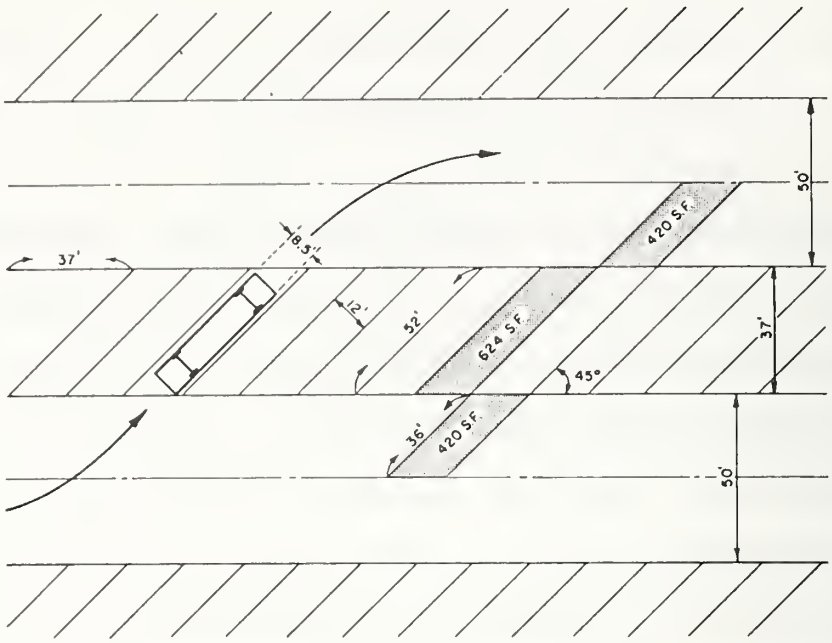
The best statistical relationship for internal parking was approximately 500 square feet per bus in the active fleet plus 2,665 square feet (Figure VI-9). This finding is consistent with the space recommendations that were cited for in-line parking that were cited earlier in this section.

SERVICE LANES

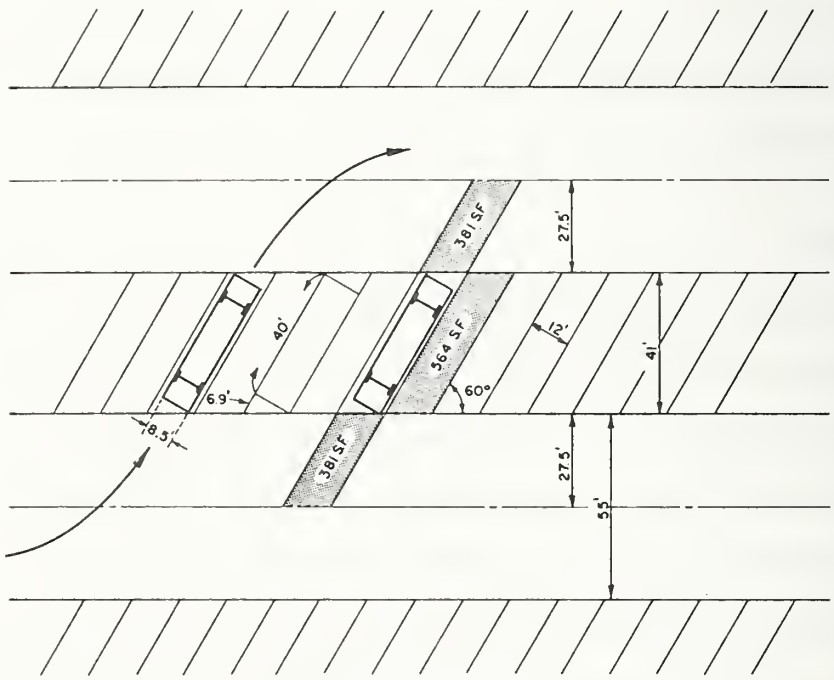
Bus servicing is a daily function for most of the active fleet. Farebox vault pulling, refueling, fluid checks, interior cleaning, and exterior cleaning are activities which are often done as part of daily servicing.

The most common servicing arrangement is an in-line pattern. The first station is vaulting; the second station is combined refueling, fluid check and interior cleaning; the third station is drive-through exterior washing. Typically, one or two service lanes are provided that by-pass the exterior wash station to accommodate servicing when washing is unnecessary.

There are variations on this basic arrangement. One variation that is popular for security is to pull the fareboxes at the front gate so no buses on



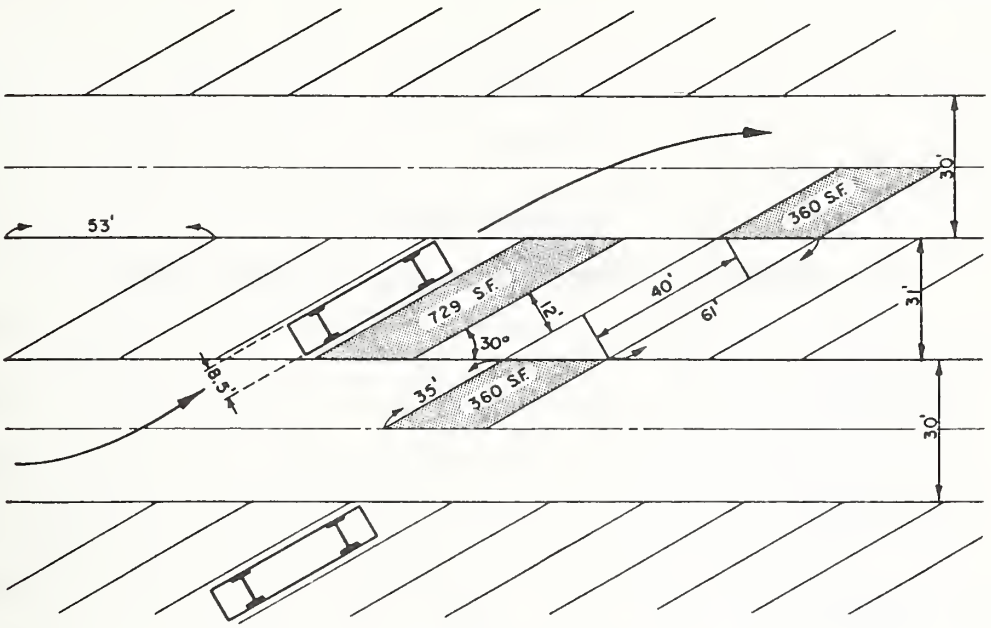
45° SINGLE BAY



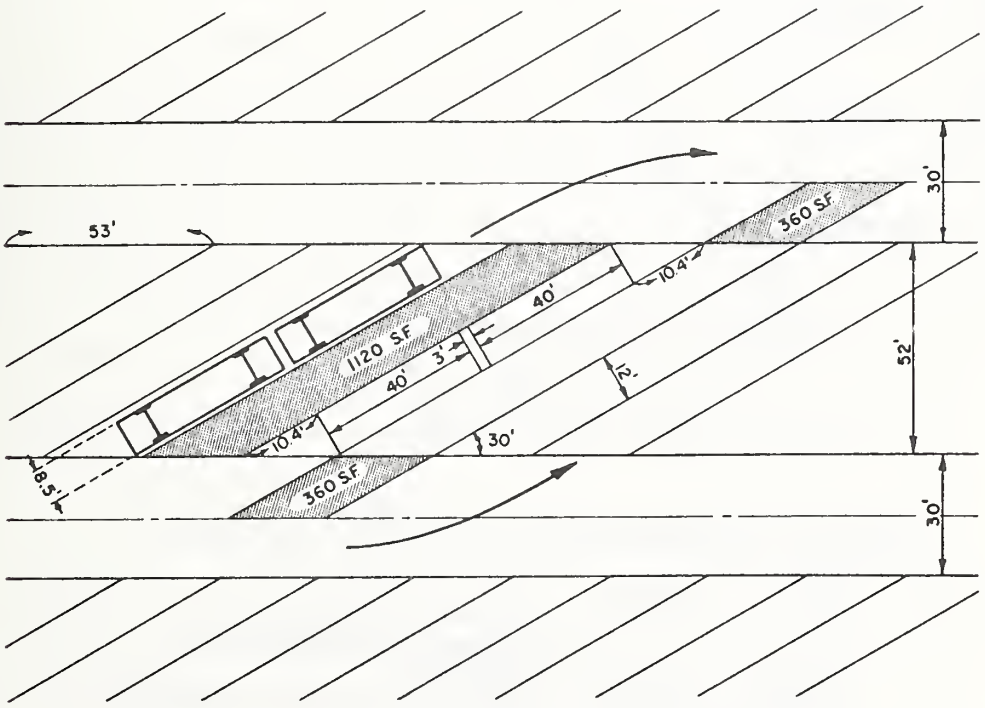
60° SINGLE BAY

SOURCE: BUS MAINTENANCE FACILITIES: A TRANSIT MANAGEMENT *HANDBOOK*, USDOT, NOVEMBER 1975.

FIGURE VI-7
BUS PARKING DIMENSIONAL CRITERIA



30° SINGLE BAY



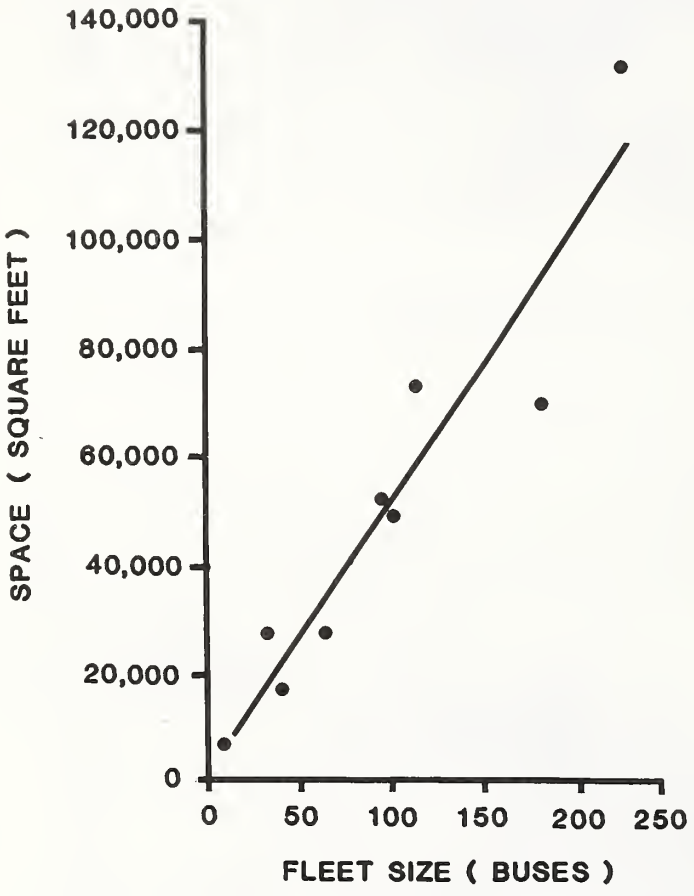
30° DOUBLE BAY

SOURCE: BUS STORAGE, MAINTENANCE, OPERATING AND GENERAL OFFICE FACILITIES, CITY OF HOUSTON, TEXAS, JUNE 1975.

FIGURE VI-8
BUS PARKING DIMENSIONAL CRITERIA

FIGURE VI-9

INDOOR VEHICLE STORAGE SPACE VS FLEET SIZE



INTERIOR PARKING SPACE REGRESSION EQUATION

$y = 496x + 2665$

(59)	(1160)	STANDARD ERROR OF REGRESSION COEFFICIENT
(8.35)	(2.30)	T-VALUE
(0.00)	(0.03)	SIGNIFICANCE OF T-VALUE

$r^2 = 0.91$ NUMBER OF CASES = 9

x = FLEET SIZE

y = INTERIOR PARKING SPACE IN SQUARE FEET

the property have cash aboard. Some systems feel this is very important and others find it sufficient to pull fareboxes in the service lanes. If fareboxes are pulled at the front gate, a driveway long enough to prevent bus queuing on the street is provided.

Another variation is to entirely segregate washing from other servicing activities. In the standard, in-line configuration, service lanes act like wind-tunnels. Spray from the washers blows back through the servicing area making an unpleasant working environment -- especially in the winter. One system that has segregated washing from other servicing activities designed a free-standing building for servicing and interior cleaning. Two wash bays were constructed at the end of the main building. The site circulation plan featured counter clockwise movement from the vaulting station at the front gate, to the service building, to the washer. Since the washer is at the end of the building, the washer by-pass route is simply around the end. This facility is in the south, so the exterior circulation is not a problem.

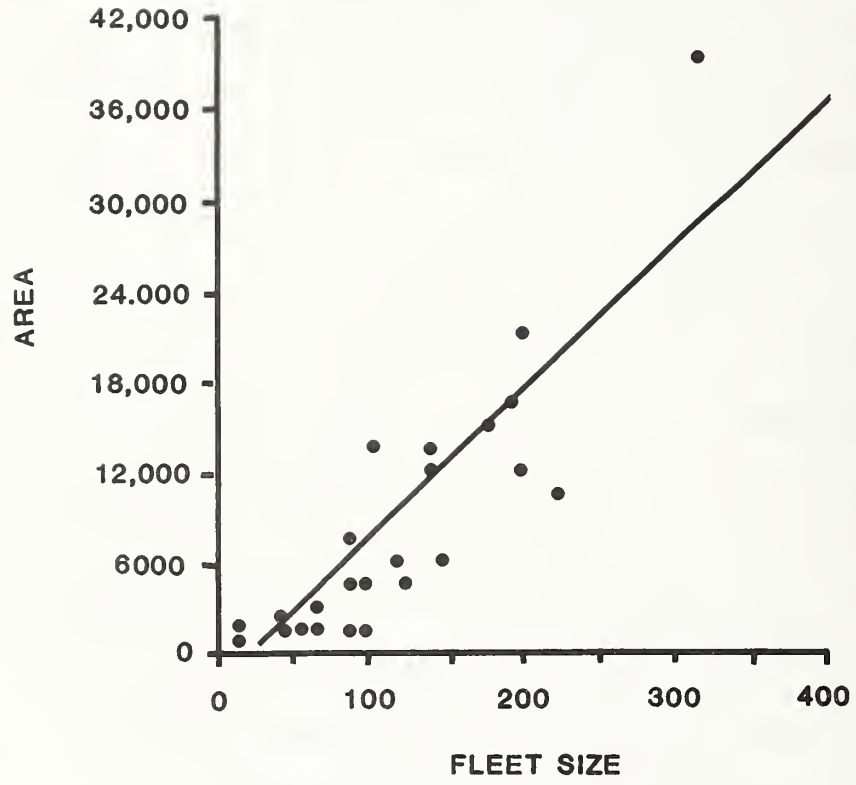
The best statistical relationship for service area was approximately 100 square feet per bus in the active fleet (Figure VI-10). Fleet size is a better independent variable than vehicle miles operated, because every bus operated is generally serviced regardless of the miles travelled.

Vaulting

Upon return from service, buses at most systems are first moved through the vaulting area to remove cash from the vehicle. Many systems have removed the vaulting function from the service lane area to a bus return area. This bus return area is usually adjacent to a secured building or office at the main garage. This area provides either a window through which fareboxes can be exchanged or equipment to empty fareboxes so they can be placed back on the bus. The advantage of a bus return area is that the driver stays with the

FIGURE VI-10

FLEET SIZE VS SERVICE LANE AREA



SERVICE AREA SPACE REGRESSION EQUATION

$y = 99x - 2,771$

(12) (1,727) STANDARD ERROR OF REGRESSION COEFFICIENT

(8.21) (1.60) T-VALUE

(0.00) (0.06) SIGNIFICANCE OF T-VALUE

$r^2 = 0.75$ NUMBER OF CASES = 25

x = FLEET SIZE

y = SERVICE AREA IN SQUARE FEET

vehicle until the cash is safely removed. This assures that the vehicle is not left unattended with money on board. After the cash is removed the driver parks his bus and goes off-duty. It is then the responsibility of the servicing personnel to move the bus through the service area.

Most facilities examined utilized manual vaulting techniques. The garages at Rockville, Maryland and Boston, however, opted for automatic cash removal systems. These systems utilize vacuum units to remove money from specially equipped fareboxes and deposit it directly into secured vaults. These units were stationed at the head of the service lane.

No data were specifically obtained on vaulting area as part of this study. Standards developed by the Chicago Transit Authority are shown in Table VI-4.

Fueling

The fueling area within the service lane consists of an island with fuel pumps and hoses. Pumps with registers are often used to keep records of fuel dispersed. While a bus is being fueled other tasks are often conducted. Fluid levels are checked, grease is injected into fittings and a visual inspection is conducted to find other obvious problems.

Again, no data were collected on the size of the fueling area alone. Table VI-5 shows standards developed by CTA and Figure VI-11 illustrates the dimensions of a typical fueling area.

Exterior Washing

Most of the facilities examined have an exterior washer in each service lane. The bus washer was generally an automatic brush type washer which cleans the tops, sides and ends of the bus. The automatic washer makes exterior washing the fastest activity of those taking place in the service

TABLE VI-4

VAULTING AREA SPACE REQUIREMENTS

Garage Capacity (Number of Buses)	Positions Required (Units)	Area Required (Square Feet)
100	2	1.500
150	2	1,500
200	3	2,100
250	4	2,720
300	4	2,720
350	5	3,330

SOURCE: Bus Garage Standardization and Rehabilitation for the Chicago Transit Authority, prepared by DeLeuw, Cather & Company, August 1977.

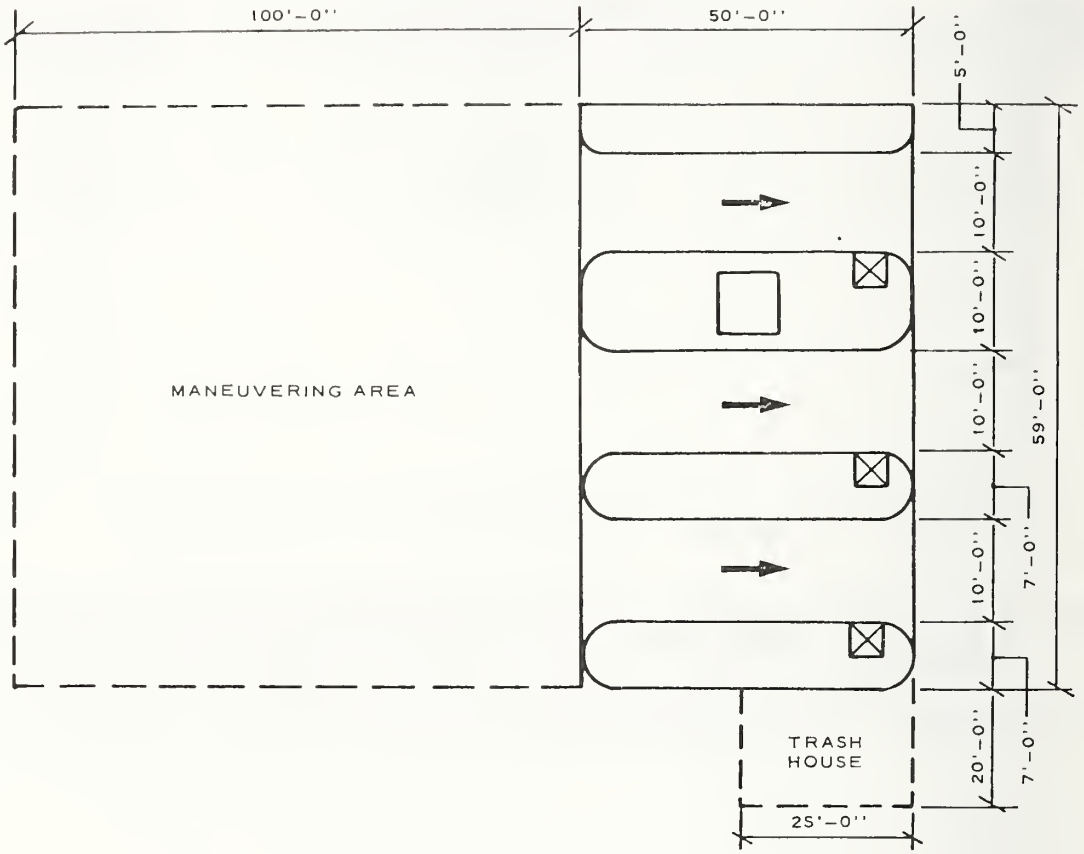
TABLE VI-5

CTA FUELING AREA SPACE REQUIREMENTS

Garage Capacity (Number of Buses)	Fueling Positions (Units)	Area Required (Square Feet)
100	2	2,600
150	3	3,450
200	3	3,450
250	4	4,800
300	5	5,650
350	5	5,650

The total area of this module includes space for trash handling.

SOURCE: Bus Garage Standardization and Rehabilitation for the Chicago Transit Authority, prepared by DeLeuw, Cather & Company, August 1977.



SOURCE: BUS GARAGE STANDARDIZATION AND REHABILITATION FOR THE CHICAGO TRANSIT AUTHORITY, AUGUST 1977.

FIGURE VI-11
REPRESENTATIVE FUELING AREA
SHOWING TYPICAL DIMENSIONS AND LAYOUT

lane. As such, in some facilities one washer unit may serve more than one service lane. If fewer washers than service lanes are provided, the service lanes are often built with piping and wiring for the addition of another washer should more washers be needed later.

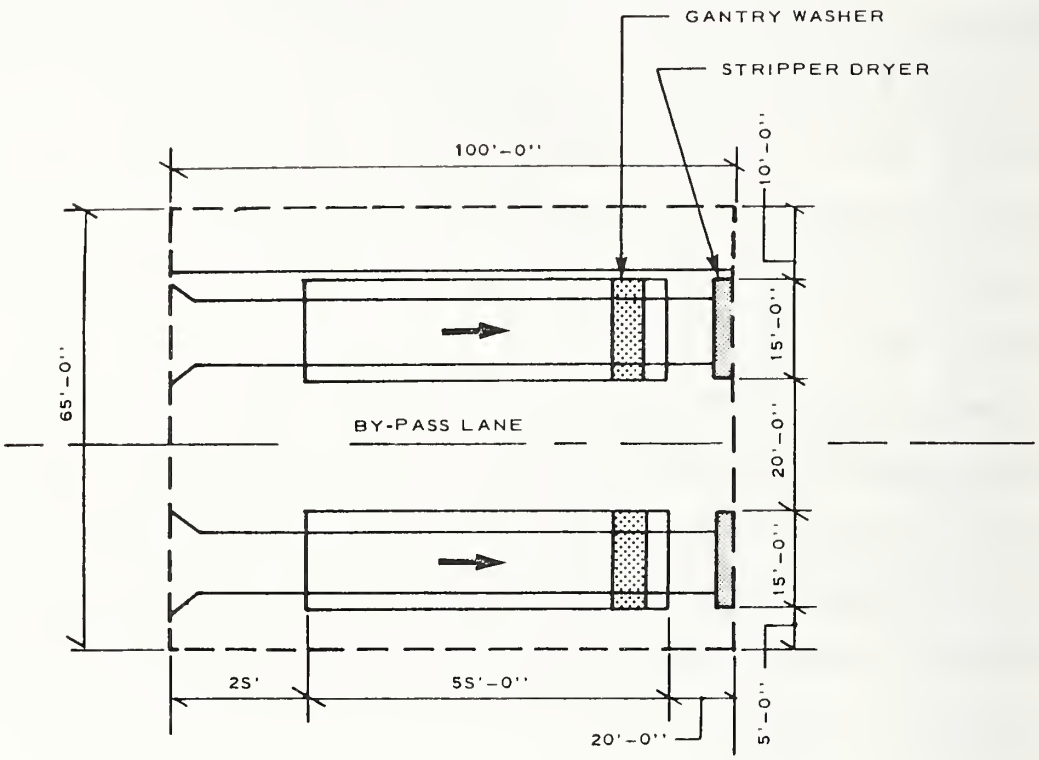
While the exterior wash is frequently included in the service lane, some systems have elected to place bus washing equipment in separate buildings. This isolates the adverse environmental conditions which result from continuous vehicle washing. In areas where winter temperatures go below freezing, the washer area is heated and is often equipped with a stationary stripper dryer which directs a high velocity hot air stream onto all exterior surfaces of the vehicle.

Figure VI-12 illustrates the dimensions and orientation of a typical bus exterior washing area. No data were assembled in this study on washing area only, but representative guidelines developed for CTA and Houston call for approximately 3,000 square feet of space per stall. The type of machinery, circulation plan and number of stalls and by-pass lanes affect the space required for bus washing.

Interior Cleaning

Interior cleaning is usually included within the service lane. Interior cleaning can be conducted utilizing vacuums, blowers, or cyclone cleaners. Transit facilities in areas with dry climates are moving away from cyclone cleaners because of the dust. Static electricity causes dust to adhere to windows and seats, which then need to be cleaned as well.

No separate space allocation data are presented for this activity, because interior cleaning generally takes place while the bus is being fueled. The space allocated for the fueling station satisfies both functions.



SOURCE: BUS GARAGE STANDARDIZATION AND REHABILITATION FOR THE CHICAGO TRANSIT AUTHORITY, AUGUST 1977.

FIGURE VI-12

REPRESENTATIVE EXTERIOR BUS WASH AREA SHOWING TYPICAL DIMENSIONS AND LAYOUT

VEHICLE INSPECTION

Like daily servicing, vehicle inspection is a frequent activity. Almost all transit systems perform thorough inspections at fixed mileage intervals which range from 3,000 to 6,000 miles. Additionally, daily safety inspections and/or brake adjustments are performed in the inspection area at some transit systems.

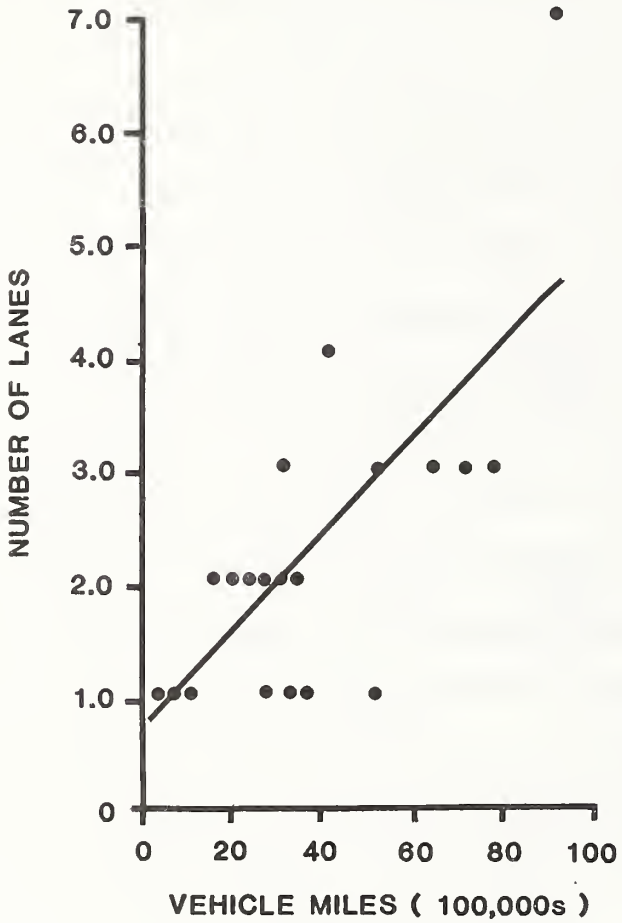
Most transit systems prefer pits for inspection because a bus can be moved over a pit more quickly than it can be raised on a hoist. Whether pits or hoists are used, inspection areas are preferably designed as drive-through lanes to minimize the time that is required to maneuver the vehicles.

The best statistical relationship was 0.045 lanes per 100,000 annual vehicle miles plus 0.667 lanes (Figure VI-13). The use of service area as a dependent variable did not produce a significant relationship, probably because most of the facilities used the drive-through design. When this design is used, the placement of exterior doors and internal circulation lanes can greatly influence the size of the inspection area.

As shown in Figure VI-13, the relationship between the number of inspection lanes and annual vehicle miles has a relatively low coefficient of determination (R^2 = 0.51). This occurs, in part, because the number of inspection lanes is a discontinuous variable. The plot in Figure VI-13 suggests that a step function may exist where an additional inspection lane is added every 1.5 to 2.0 million annual vehicle miles.

FIGURE VI-13

INSPECTION LANE AREA ANALYSIS



INSPECTION LANE REGRESSION EQUATION

$y = 0.045x + 0.667$

(0.010) (0.393) STANDARD ERROR OF REGRESSION COEFFICIENT

(4.64) (1.70) T-VALUE

(0.00) (0.05) SIGNIFICANCE OF T-VALUE

$r^2 = 0.51$ NUMBER OF CASES = 23

x = ANNUAL VEHICLE MILES IN 100,000'S

y = NUMBER OF INSPECTION LANES

VII. HEAVY MAINTENANCE FACILITIES

Data were assembled for only five modern heavy maintenance facilities during this research. That is too few to support statistical analysis, so raw data on space allocation, number of work areas, and personnel are presented in this chapter. This provides examples of heavy maintenance facilities of several sizes that may prove helpful to future designers of such facilities. It was not possible to assemble enough data to develop guidelines in the same manner as was done for operating garages in the previous chapters. When planning ratios are calculated, they are on a per-bus basis rather than a vehicle mile basis, because consistent system-wide data on vehicle miles operated could not be obtained.

There are two basic types of heavy maintenance facility -- free-standing facilities that house no resident fleet and joint heavy maintenance/operating garages. Free-standing facilities are found in large transit systems that have several operating garages. Combined heavy maintenance/operating garages are found at multiple facility properties of varying sizes. The choice of a free-standing or joint facility is partially related to total system size and partially related to existing facilities.

Five heavy maintenance facilities were examined as part of this project:

- o Free-standing maintenance facilities in Atlanta and Minneapolis
- o Combined heavy maintenance/operating facilities in Phoenix, Albany and Seattle.

The functions carried out are largely the same in all five and are generally the same as the heavy maintenance element of single facility property garages. In fact, combined heavy maintenance/operating garages are very similar to single facility garages -- all of the maintenance functions are present plus

driver support facilities in the transportation division. The major difference is that the facility supports the entire system fleet, not just its own operating fleet. The transit system's fleet of autos and trucks is generally maintained at the heavy maintenance facility as well.

As shown in Table VII-1 the patterns of bay allocation and personnel allocation are very different for free-standing facilities and joint facilities. Joint facilities have more maintenance personnel and more repair bays on a per bus basis than do free-standing facilities, because joint facilities must perform routine inspections and light repair as well as heavy repair functions. The measures for joint facilities shown in Table VII-1 are more akin to those found for single facility properties than for heavy maintenance facilities. Five to six buses per mechanic and eleven buses per maintenance bay are within the range that was found for single facility properties. The free standing facilities, on the other hand, have higher mechanic and bay ratios than joint facilities. At those facilities there are over 30 buses per heavy repair bay in the main shop and each mechanic supports over nine buses.

The Seattle facility is in line with the other two combined facilities in all categories except buses per general repair bay and buses per body repair bay. One bay appears to support more buses in Seattle than in Phoenix or Albany. The reason for this is that Central Base in Seattle does some heavy maintenance for two operating garages but does not do all heavy maintenance. There is a rebuild shop at another location that supports the entire fleet. Central Base functions like a division garage, providing some but not all maintenance support for buses operating out of two facilities.

Table VII-2 presents a detailed summary of bay and lift allocation by function. Functions are broken out in detail, but every facility does not use

TABLE VII-1

SUMMARY INFORMATION
HEAVY MAINTENANCE FACILITIES

	Free Standing		Combined Heavy Maintenance and Operating		
	Atlanta	Minneapolis	Phoenix	Albany [1]	Seattle
System Bus Fleet	740	1066	250	230	330
System Auto and Truck Fleet	120	74	NA	NA	100
Maintenance Personnel					
Foremen	9	5	5	3 (1)	NA
Mechanics	80	92	50	38 (19)	52
Cleaners and helpers	11	0	25	21 (2)	41
Administration and Parts	10	25	9	NA	13
Total	110	122	89	62 (22)	106
Bus Repair Bays	15	31	22	21	15
Bus Body and Paint Bays	42	15	5	3	2
Total Bus Bays	57	46	27	24	17
Total Bus Lifts	17	19	16	16	9
Total Bus Pits	3	4	3 [2]	0	2 [2]
Total Auto Bays	6	7	0	0	3
Total Auto Lifts	6	5	0	0	3
Measures					
Buses/Mechanic	9.3	11.6	5.0	6.0 (12.1)	6.3
Buses/Total Maint. Personnel	6.7	8.7	2.7	3.7 (10.5)	3.1
Buses/General Repair Bay	49	34	11	11	22
Buses/Body Shop Bay	18	71	50	77	165

1. Employee numbers in parentheses are assigned to the heavy maintenance part of the facility only.

2. Inspection only.

TABLE VII-2

DETAILED ALLOCATION OF WORK BAYS
HEAVY MAINTENANCE FACILITIES

	Free Standing		Maintenance and Operating		
	Atlanta	Minneapolis	Phoenix	Albany	Seattle
General Repair					
Bays	3	10	14	17	9
Lifts	3	0	10 3/	13	7
Pits	0	0	0	0	0
Bus Rebuild					
Bays	6	12	0	3	0
Lifts	6(Portable)	7	0	2	0
Pits	0	4	0	0	0
A/C Repair					
Bays	ND	ND	4	ND	ND
Lifts	ND	ND	2 4/	ND	ND
Body Repair					
Bays	32 1/	11	3 1/	2	1
Lifts	2	11	2	1	0
Pits	3	0	0	0	0
Paint					
Bays	4 2/	2	2	1	1
Lifts	0	0	0 5/	0	0
Paint Prep and Finish					
Bays	6	2	1	0	0
Brake Repair					
Bays	6	9	1	ND	1
Lifts	6	8	1	ND	1
Steam Clean					
Bays with Lifts	0	2	1	0	1
Engine Dynamometer	1	ND	1	0	0
Tire Repair					
Bays	ND	ND	1	1	1
Lifts	0	ND	1	0	0
Auto and Truck Repair					
Bays	6	7	0	0	3
Lifts	6	5	0	0	3

TABLE VII-2 (CONTINUED)

DETAILED ALLOCATION OF WORK BAYS
HEAVY MAINTENANCE FACILITIES

FOOTNOTES

1. All bays in Atlanta equipped with floor tie downs. One bay in Phoenix equipped with floor tie down.

2. Two paint lanes. Each equipped with one paint booth for base coat and second booth for striping.

3. Three lifts able to accommodate articulated buses.

4. Both bays able to accommodate articulated buses

5. Paint preparation bay and two paint booths are in-line. First paint booth is equipped with a drop table; second has a rolling scaffold.

Note: ND (Not Designated) indicates the function is not performed in specially designated bay.

the same scheme. Zero entries indicate that special facilities for performing a function are not present; "ND" indicates there is no specially designated area, but the function may be performed at the site in general repair bays.

Some explanation of policy differences is in order to highlight reasons for variations in space allocation. The Seattle garage has most bays in a general repair area as does Albany. Functions are allocated to bays by the manager. Atlanta and Phoenix have opted for greater differentiation. Atlanta's three general bays are used primarily for engine/drive train removal and installation. Buses due for rebuilt components use these bays. Six bays are used for brake repair, supported by two adjacent brake lathes. The majority of brake work for the system is done here. Phoenix has divided general repair into seven bays each for light repair and heavy repair plus four separate air conditioner repair bays. Phoenix uses the heavy repair section for major engine and drive train work, and has a disassembly area, cleaning area, and rebuild shop immediately behind the bays.

Atlanta clearly performs a high volume of body work at the main facility. Thirty-two bays are available, arranged in 16 sets of two-deep bays. Some buses remain in the shop for a relatively long time, depending on the severity of body damage, accounting for the large number of bays. Atlanta also has a high volume painting operation. Albany and Phoenix have paint shops consistent with the size of fleet operated.

None of the properties have chassis dynamometer bays, but Atlanta and Phoenix are equipped with engine dynamometers for testing rebuilt engines

Atlanta and Albany also have rebuild programs. Atlanta is using a separate six bay work area for rebuilding buses. These bays have no lifts, so portable lifts are used. Albany has dedicated three bays in a corner of the general repair bay area for rebuild.

Table VII-3 shows the actual space allocation in square feet to maintenance functions. Most of the space allocations are approximate multiples of a basic bay module of approximately 1,000 square feet -- 50 feet x 20 feet or 60 feet x 18 feet. The column spacing in these buildings is a multiple of either 18 or 20 feet in most cases, so maintenance bays can fit between the roof support columns.

The data in Table VII-3 show reasonable consistency across the properties shown. The smaller work shops are roughly the same size in most cases. The welding shop or electrical shop, for instance, usually employs only one or two people. The size of the work area is related to the equipment and work space needed for the crew to work rather than directly to fleet size. One such shop can support an entire fleet up to the 700 bus range.

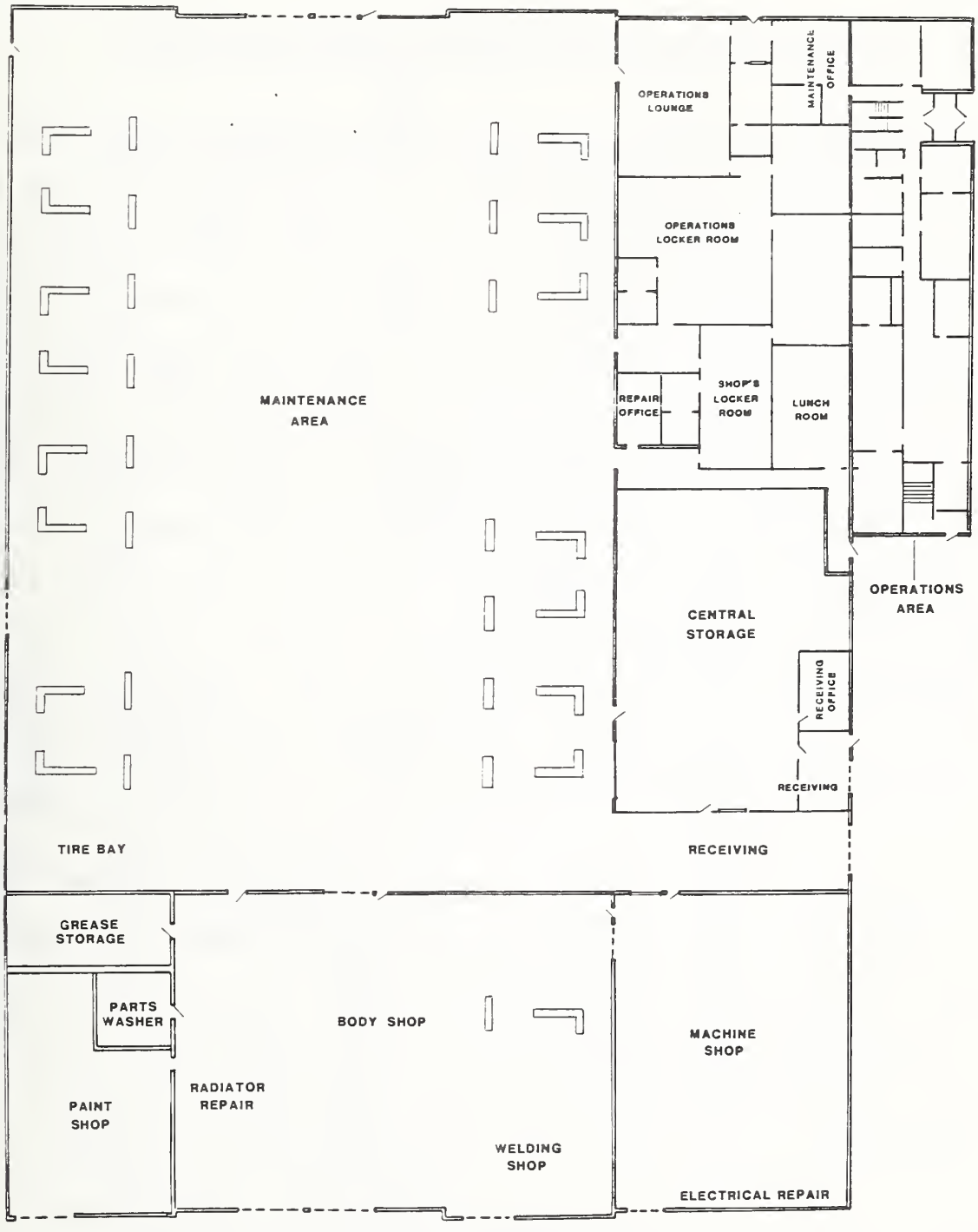
The most noticeable variation in Table VII-3 is in allocation of general repair space. Seattle, Atlanta and Phoenix use head-in bays, each with direct outside access and no internal circulation. Albany has much higher space allocation for general repair than the others. The reason for this is that Albany has a large, open repair area with 90 degree bays on both sides and center circulation. The entire area is 160 feet wide, allowing approximately 60 feet in the center for turning and circulation. This circulation area is not wasted, however. The area behind bays where buses are not moved in and out daily (e.g., rebuild and some heavy repair) is used for repair that does not require a lift or for "drip dry" in the winter months. The other facilities are all located in mild climates where the need to provide unstructured inside space is not a major factor. Figure VII-1 shows the "open plan" of the Albany facility and, for comparison, Figure VII-2 shows the more structured plan used in Phoenix.

TABLE VII-3

MAINTENANCE SPACE ALLOCATION

	Free Standing		Maintenance and Operating		
	Atlanta	Minneapolis	Phoenix	Albany	Seattle
General Repair Bays	14,280	2,640	20,735	33,000	18,614
Inspection Lanes	ND	ND	7,300	ND	8,000
Body Shop and Bays	43,200	48,600	7,319	3,550	3,300
Air Conditioning Shop	ND	3,100	5,400	ND	ND
Paint Bays	17,940	5,184	5,153	2,000	2,000
Brake Bays and Shop	13,700	20,600	1,800	ND	2,000
Tire Bays and Shop	ND	500	3,372	800	2,975
Dynamometer	0	ND	450	0	0
Steam Cleaning	1,850	2,880	2,150	0	2,250
Parts Cleaning	1,073	2,246	700	400	250
Overhaul and Machine Shop	21,420	46,600	5,400	4,240	600
Welding Shop	2,590	1,290	250	400	375
Electrical Shop	ND	1,728	405	400	600
Radiator Shop	ND	1,080	360	1,600	0
Battery Room	0	144	380	0	275
Parts Room	22,230	900	9,788	4,640	3,700
Storage	3,342	77,100	3,601	800	3,079
Receiving Dock	4,455	4,860	0	1,160	0
Maintenance Offices	2,725	4,000	1,035	721	602
Lockers and Showers	7,380	2,448	1,696	931	1,608
Toilets	445	1,620	790	250	400
Lunchroom	ND	960	700	540	655
Building Support	ND	3,456	288	ND	2,399

Note: ND means space not designated.



MASTER FLOOR PLAN

FIGURE VII-1

WATERVLIET HEAVY MAINTENANCE AND OPERATING GARAGE ALBANY, NEW YORK

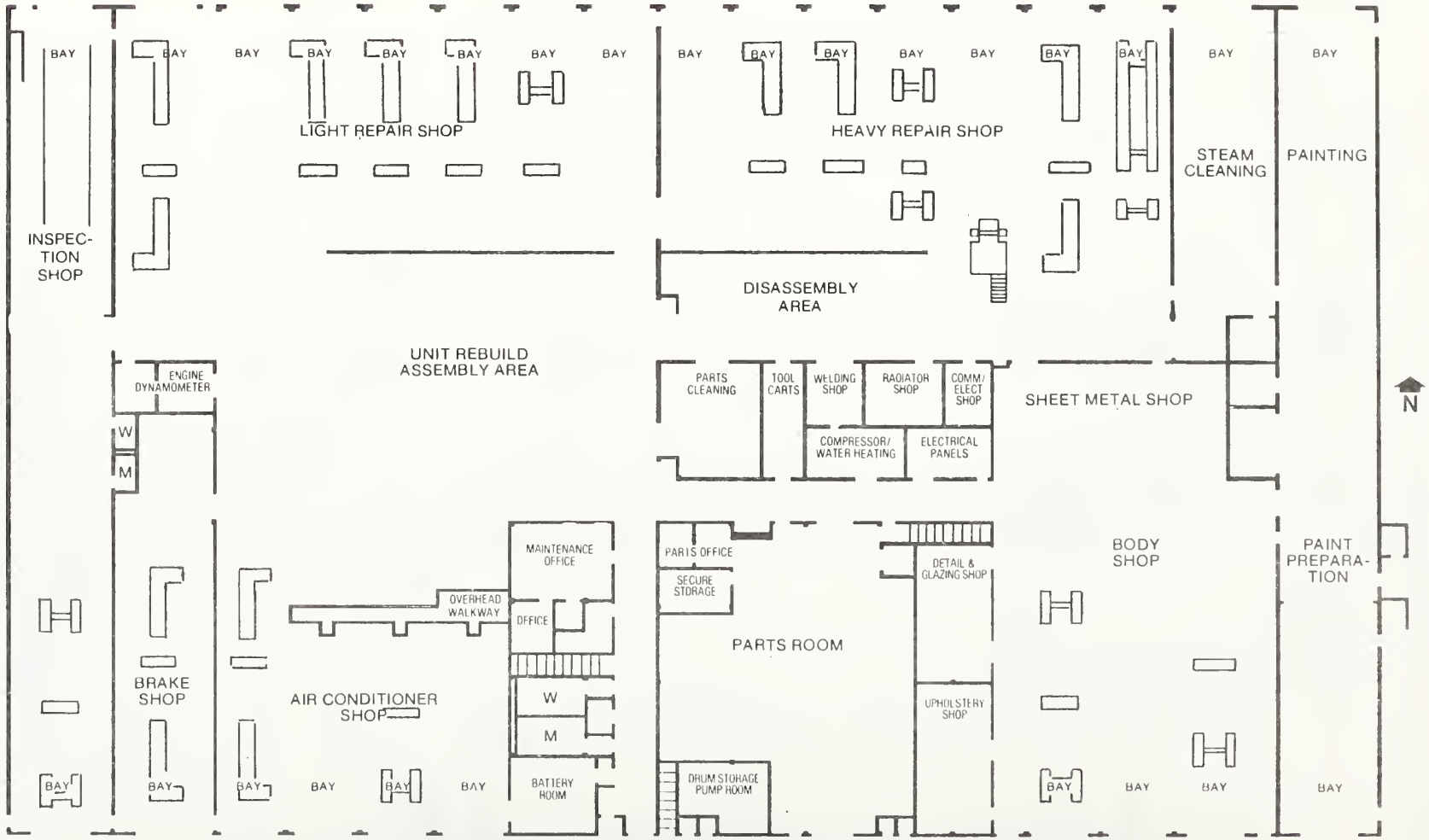


FIGURE VII-2

PHOENIX SOUTH-HEAVY MAINTENANCE AND OPERATING GARAGE
PHOENIX, ARIZONA

VIII. SELECTION OF THE BEST FACILITY ALTERNATIVE

Most transit systems develop and examine a number of alternative plans for meeting their bus facility needs. A variety of new facility alternatives which involve different locations, facility configurations (e.g. one central vs. two decentralized maintenance facilities) and size(s) of facilities are often considered. In addition, some alternatives include considering the rehabilitation of existing facilities. An analysis method is needed to select the best alternative. The selection methods used by transit systems are described in this chapter. Most transit systems use some form of economic analysis to determine the type(s) and general locations of bus facilities. The use of economic analysis in facility selection is discussed in the first section of this chapter. The remaining section of the chapter covers the two general analysis approaches used by transit systems to select facility site locations.

ECONOMIC ANALYSIS

Almost all transit systems use economic analysis to aid them in the selection of the best alternative. The objective of the analysis is to find the action that is least expensive over the expected life of the project in terms of both capital expenditures (for construction or rehabilitation) and operating expenses (incurred annually).

The techniques used for such an analysis treat current capital costs and expected future costs or benefits on an equivalent basis either by discounting the value of expected benefits or by converting the capital costs into equivalent annual costs. These methods are known, respectively, as "net present worth" analysis and "annual cost" analysis.

In simple terms, the annual cost method converts the initial capital cost into an equivalent annual cost using a capital recovery factor yielding the annual amount (principal plus interest) that would have to be paid to cover the investment plus opportunity value of money (similar to interest rate). The net present worth method converts annual operating costs into a value at the current time equal to the amount of money that would need to be invested today in order to meet operating expenditures in each year of the life of the facility.

When conducting an economic analysis transit systems assess:

- o Cost of rehabilitation of existing facility
- o Cost of building new facility at each potential site
- o Useful life of each investment
- o Cost of operations at each potential facility including plant operations (e.g. plant maintenance) and transportation costs (deadheading, relief).
- o Opportunity cost of money (similar to the real interest rate). Effects of inflation are generally not included.

The costs of rehabilitation or new construction are often developed from engineering studies. Cost estimates for rehabilitation are based on bringing the facility to standards such as those discussed in Chapters III through VII so that only routine maintenance will be required for the design life of the facility. This design life is the same as that used for analysis of a new facility. Detailed capital costs for a new facility are often based on the average square foot costs of similar construction in the urban area and/or of similar facilities at other transit systems.

The useful life of an individual facility such as a maintenance garage is generally considered to be forty years. This is sometimes called the "economic life" of a facility. This rule-of-thumb has developed over years of

experience with industrial buildings, but can be calculated independently if desired. Texts on Engineering Economy discuss accepted methods. As a practical matter, forty years is sufficiently long that the capital recovery factor (the value used to annualize costs) approaches the value of the interest rate used. For instance, the capital recovery factor for forty years at ten percent interest is 0.10226, very close to the interest rate of ten percent. This is similar to saying that the building is fully depreciated. While a facility may continue to be used beyond its economic life, forty years is a reasonable number for economic analysis. The Urban Mass Transportation Administration requires, at the time of this writing, that a ten percent interest rate be used in economic analysis of transit investment.

The annual costs of plant operations include all functions that occur within the facility such as energy cost and bus repair costs. In situations where the only alternatives considered are those involving new construction of a single facility, these costs are often assumed to be equal for all sites and are not considered in the analysis. If the analysis compares "do nothing" to new construction, the cost inefficiencies of the old facility are considered in the operating cost analysis.

The annual cost of plant maintenance includes all functions required for upkeep of the physical facility. Like the costs of plant operations, plant maintenance costs are often excluded from the analysis in situations where the alternatives consider only the construction of a single new facility.

Transportation costs are costs related to the operation of the buses including such items as driver wages, fuel and tire wear. Transportation costs can be divided into those incurred in revenue and non-revenue service. The costs of providing revenue service are not included in the analysis because they do not vary with facility location. Non-revenue service costs,

e.g. pull-on/pull-off operations and relief (if used), are included because they are directly related to facility location.

If the present worth method of economic analysis is used, then the analysis is designed to find the facility and site alternative having the lowest value for the net present worth of costs. The expression is:

$$\text{Net Present Worth of Costs} = CC_i + PWF(AO_i) + PWF(AC_i) + PWF(TC_i)$$

where:

CC_i = capital cost of rehabilitation or new construction for alternative i

AO_i = annual plant operating costs for alternative i

AC_i = annual plant maintenance costs for alternative i

TC_i = annual non-revenue operating costs for alternative i

PWF = present worth factor

$$= \frac{(1 + i)^n - 1)}{i(1 + i)^n}$$

where costs are uniform for each year, where:

i = interest rate (e.g. 10% = 0.10)

n = number of years

If any of the future cost elements, AO_i, AC_i or TC_i, are expected to vary over time then a more complex method of computation is used; present worth costs for each year are calculated individually. Most transit systems assumed that future costs would remain constant and did not use the more complex method.

The annual cost method yields the same decision as the present worth method, but converts all costs into an equivalent annual amount over the life

of the facility. In this case capital costs are annualized using the capital recovery factor as follows:

Equivalent Annualized Cost: $CC_i(CRF) + AO_i + AC_i + TC_i$

when:

CC_i, AO_i, AC_i and TC_i are the same as above

CRF = Capital Recovery Factor

$$= \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

where costs are uniform for each year, where:

i = interest rate

n = number of years

As with the present worth method, if AO_i, AC_i or TC_i vary from year to year a more complicated analysis is necessary. Assuming future costs to be constant is the common practice. Values of the capital recovery factor are available in tables or in built-in computer functions.

ANALYSIS METHODS FOR SITE LOCATION

The aim in finding a site for a new facility is to minimize the capital cost of constructing and equipping the facility, the annual costs of operating the facility, and the vehicle operating costs (deadhead costs, relief cost) associated with bringing vehicles into and out of revenue service.

The major variable in capital cost is the price of land. Unless a specific land parcel has unusual conditions (e.g., poor soils) the cost of constructing and equipping a facility for a given number of buses in a given region is assumed not to vary greatly with the site chosen. Similarly, the internal operating costs of a facility of a given size performing common functions are assumed not to vary significantly with location. The major

variable cost element is assumed to be deadhead operating costs. Most methods used by transit systems focus on these costs.

Deadhead costs can be significant. Transit systems focus on deadhead costs, because they occur over the entire life of the facility. Over the 40 to 50 year life of a facility, small differences in annual deadhead costs can easily outweigh the typical differences in the costs of purchasing alternate parcels of land.

The magnitude and nature of deadhead costs vary among transit systems because of differences in operating policies and labor contract provisions. The cost components are:

- The mileage-related costs of bringing vehicles from the storage facility into revenue service and returning vehicles to the garage at the end of revenue service.
- The hour-related costs (primarily drivers wages) of bringing vehicles into revenue service and returning the vehicles from revenue service to the garage.
- The costs (wages) incurred for on-route relief of drivers. (In some systems there is little or no relief. At the end of an operating period the driver and the vehicle return to the garage. A new driver and vehicle are dispatched to continue service.)

To minimize the costs of facility operation, the facility must be located so that the time and distance, and therefore the costs of deadhead operations, are minimized. Two general approaches have been used by transit systems for this analysis. In the first approach all of the feasible locations for facilities are identified. The operations costs for each location are estimated, and the lowest cost location is selected as the best location. The steps in the second approach, the global approach, are just the opposite of those in the first approach. All locations in the area are considered potential locations. An analysis is made of operating costs at all locations, and then the area where the bus facility would be most efficient is identified.

Other feasibility criteria are then used to select a specific parcel of land. Both of these approaches are discussed in the following paragraphs.

IDENTIFY FEASIBLE LOCATIONS APPROACH

The approach of first identifying the feasible locations and performing the cost analysis only for those locations is the most common approach used by transit systems. This method relies heavily on judgment in the first step of identifying feasible locations. In an attempt to make this step more systematic a number of transit systems have developed feasibility criteria. The most common criteria include:

- o Availability
- o Size and shape of parcel
- o Zoning
- o Soil conditions
- o Roadway access
- o Availability of utilities
- o Noise and air quality impacts

Availability

Some public transit agencies have the power of eminent domain, which enables them to acquire land for transit facilities even if the owners do not wish to sell. However, it is obviously quicker and easier to acquire a site that is already on the market or one that can be acquired through negotiation rather than condemnation.

Local cash expenditure is another consideration. From a purely economic viewpoint, the cost of land over the life of a project is equivalent whether it is converted from other public use or purchased specifically for the project, because land has full salvage value at the end of project life. The

only true cost is the opportunity cost of the money used to purchase the property.

From a cash flow perspective, however, the situation is quite different. No cash is required if the land is already in public ownership. In fact, the local area can reduce its total cash requirement by treating the land as an in-kind contribution to match federal grant funds. Hence, sites already in public ownership are given substantial preference when selecting a site for a storage and maintenance facility.

Size and Shape of the Parcel

Forecasts of future fleet size and operation needs determine the size for an acceptable site. Although some "squeezing" of operations may be possible, transit systems generally do not feel it is desirable when embarking on the construction of a facility having a forty to fifty year life span. In recent years, the tendency has been to design for fleet expansion.

The shape of the parcel can be a limiting factor; facilities typically are developed on parcels that are square or rectangular. Long, thin sites have been avoided by most systems as they lead to lengthy walking distances (say, between vehicle parking areas and maintenance functions). Oddly shaped sites may create difficult vehicle maneuvering patterns or inefficient use of the available land.

Zoning

Bus storage and maintenance facilities are unique uses that may not be explicitly included in local zoning codes. Typically, they are classified as either light industry or transportation-related, although the designation may vary. When selecting a parcel for development most systems have attempted to select a site that is already zoned for a use permitting bus maintenance

operations. Such a choice not only reduces time, paperwork and local conflict but facilitates the Environmental Impact Assessment process, as sites zoned for industrial or transportation uses qualify for a categorical exclusion from the need to prepare a formal Environmental Impact Statement.

Soil Condition

Although the structural loads developed by the buildings and parking areas of a bus depot are small compared to many engineering works, the soils on the site must be adequate to support design loads without substantial modification. Bringing poor soil up to standard can add significantly to the cost of construction and has been avoided in constructing new facilities.

Drainage

Adequate drainage is of particular importance for a bus facility. The nature of the site development leads to large, nearly flat areas of impervious surface either as building roof or as parking area. Substantial quantities of water must be removed. Since maintenance facilities usually have underground tanks for storing various types of fluids (e.g., diesel fuel, gasoline, oil, waste grease) flooding or infiltration could contaminate the stored materials or could lead to pollution of run-off water. Some properties have found it necessary to build retention basins to control the rate of water run-off from the site. The specific requirements are generally specified by local ordinance.

Roadway Access

A prime function of a facility is the dispatching of vehicles to revenue service and receiving vehicles back from service. Since much attention is paid to finding sites that minimize the deadhead travel times, these time savings must not be wasted due to congestion or other impediments. When

selecting sites for new facilities, transit systems avoid locations near heavily congested road segments or intersections located near intermittent barriers to travel (e.g., railroad crossings or drawbridges). In addition, for the sites studied, extensive travel through residential neighborhoods has been avoided, in order to minimize noise and vibration impacts.

Some agencies include a location near downtown in their site review criteria. This reflects an implicit judgment that, in a one garage system where routes are roughly centered on downtown, a central location will tend to reduce deadheading. Such implicit judgments may not account for all factors influencing non-revenue operating costs.

Availability of Utilities

When feasible, sites selected for maintenance facilities are served by utilities (sewer, water, gas, electric) of sufficient capacity for the planned uses. If utilities are not available, costs that would be incurred to extend utility service must be included in the site analysis.

Noise and Air Quality Impacts

Bus storage and maintenance facilities generate noise due to bus operations at periods when such noise is readily apparent (e.g., early in the morning and in the evening hours). Noise attenuation measures such as walls, landscaping, berms or even enclosure of the entire facility have been used, but these measures are costly and not fully effective. Properties have tended to avoid these problems by selecting sites where the noise generated will not impact on sensitive receptors.

Similarly, bus emissions can lead to localized air quality degradation. Steps to reduce emissions are desirable, but there are limits to their effectiveness. Again, the strategy has been to select sites where bus emissions will not violate ambient air quality standards.

Economic Analysis of Site Location

Only sites that survive all levels of screening on the criteria discussed above are subjected to rigorous economic analysis when the "Identify Feasible Location Method" is used. There are usually three or four sites that are serious candidates at this point. Assuming that operating and maintenance costs would be about the same at each site, analysis of deadheading costs is the major remaining task. Two approaches have been used.

Manual Measurement Method -- In this method, the distance from each potential garage location to the "point of effective service" on each route served from the garage is measured on a map. The "point of effective service" is where the bus goes into service on a particular route. Using an average speed assumption, the time required is calculated. Using the master schedule, the number of pull-outs and pull-ins to each route is determined for an entire service day. The number of pull-outs and pull-ins is multiplied by the miles and hours associated with each deadhead movement, and is summed across all routes to yield total vehicle miles and hours associated with deadheading for each garage location. A standard incremental cost model based on vehicle miles and hours is used to estimate the costs incurred.

Summation of Pull-out and Pull-in Times -- This method is sensitive to the fact that some deadheading movements have a higher labor cost associated with them due to the nature of transit labor agreements. It is a refinement of the manual method described above.

In most transit operations the cost of driver hours devoted to a morning pull-out (i.e. taking the vehicle from the garage to revenue service at the start of the work day) and the afternoon pull-in (i.e. returning the vehicle to the garage at the end of the day) will be more costly than other deadhead

operations. This occurs because such operations tend to result in a longer work day for the driver -- a longer elapsed time from sign-in to completion of work. As a result, payment of "spread time" penalties (i.e. payments made because of the total length of the work day rather than the actual hours worked) or overtime is more likely.

To utilize this procedure, distances are measured and travel times calculated as in the manual method. In addition, the total elapsed time from pull-out to pull-in must be calculated for each bus to determine if the pull-in occurs inside the minimum time guarantee. If it does, no additional labor charges will accrue for the pull-in; only mileage-related costs will accrue.

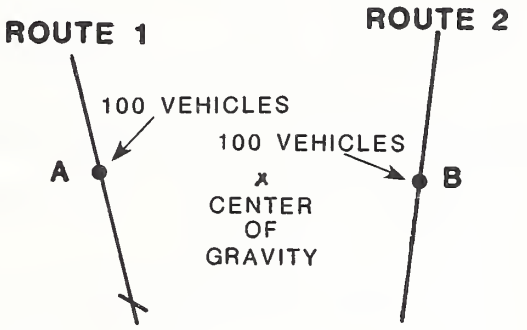
GLOBAL SEARCH APPROACH

The global search approach reverses the procedure followed in the "identify feasible locations" approach. In this approach all sites in the area are considered possible locations and the "best" garage location is selected. An actual site is then identified as close as possible to the "best" location, employing the site selection criteria discussed earlier. Two general approaches are used:

Route Centroid Center-of-Gravity[1/] -- This procedure involves dividing the service areas into sectors and finding the "most efficient" garage site for each sector. All points at which vehicles enter revenue service on a bus route are identified. A single "central point" -- referred to as the center-of-gravity -- is identified by weighting each entry point by the number of vehicles entering at that point. For example, if 100 buses enter service at

1. Gilman, W. C. and Company, Milwaukee Transit Facilities Requirements, Prepared for City of Milwaukee, Wisconsin, June 1979.

point A and 50 buses at point B, the center-of-gravity would be one-third of the distance between A and B. Alternately, if 150 buses entered at A and only 50 at B the center-of-gravity would be one-quarter of the way from A to B.



Having defined for each route in a sector the "center-of-gravity," the approximate "best" facility site is determined by finding the point that minimizes direct ("as the crow flies") vehicle miles. Mathematically, this point is located at point x, y computed as

$$\bar{x} = \frac{\Sigma\, x_i\, w_i}{\Sigma\, w_i} \quad ; \quad \bar{y} = \frac{\Sigma\, y_i\, w_i}{\Sigma\, w_i}$$

where w equals the number of vehicles entering service on route i.

For an area having a regular grid street pattern and roughly uniform travel speeds (as was the case in the referenced study) this method may yield sites that are reasonably efficient but will not yield the optimum location. For example, consider the first case of the preceding illustration. If points A and B are 1.0 mile apart, the center-of-gravity is 0.33 miles from point A; the distances travelled are (100 vehicles x 0.33 mile) + (50 vehicles x 0.67 mile) = 66.5 miles. However, locating the facility precisely at A would yield

distances of (100 vehicles x 0 miles) + (50 vehicles x 1.0 mile) = 50 miles. In this case the "center-of-gravity" is a less than optimum location.

One further problem with this method is that it does not explicitly consider the question of which routes should be operated from which facility. Rather, having determined an initial set of efficient sites for all sectors, actual deadhead miles are computed. Based on judgment, some routes are shifted to different sectors until an efficient allocation of routes to depots having the lowest deadhead mileage is found.

Network-Based Method -- To implement this method daily bus operations are examined to determine where vehicles enter and leave revenue service. Network analysis techniques such as those developed by UMTA and the Federal Highway Administration (e.g., UTPS, Planpac) are used to determine the cost of deadheading, based on time and distance, over the highway system from each facility site to all points at which vehicles enter and leave service. Penalties for additional spread time payments are added as required. Relief costs are computed separately.

The costs of serving each block (i.e. the duties of one vehicle) are computed for each traffic analysis zone. Using linear programming, the best allocation of blocks to zones is determined. Additional constraints assure that both maximum capacity and minimum efficient vehicle housing values are met. An actual site is then selected near the optimal zone.

An extension of this general method used by the Southeastern Pennsylvania Transportation Authority ("Depot Locations and Capacities Study" (1982), involves using computerized techniques to determine travel time, travel cost and travel distance from all portions of the study area to all points at which vehicles enter and leave service as well as the cheapest relief point for every route from every possible depot site. This was accomplished using

network analysis software distributed by the Urban Mass Transportation Administration and the Federal Highway Administration. Special procedures were used to account for the higher cost of driver work that could result in spread time payments as well as other special conditions of the labor agreement. The procedure also determined on a case by case basis whether it would be cheaper to relieve on route or to schedule a pull-out/pull-in.

The optimization routine identified the set of garage sites (from a set of over 500) and the allocation of routes (approximately 250) to garages that yielded the lowest annual cost, considering construction, facility operations and transportation. Maximum and minimum garage size constraints were applied as well as constraints on the peak to base ratio necessary to insure that the straight run provisions of the labor contract could be met.

FLOOR PLANS AND KEY INFORMATION FOR SELECTED BUS MAINTENANCE FACILITIES

APPENDIX TO BUS MAINTENANCE FACILITY PLANNING STUDY / STATE-OF-THE-PRACTICE

PREPARED BY SG ASSOCIATES, INC. / CLARK, NEXSEN, OWEN, BARBIERI AND GIBSON / USDOT-UMTA / PROJECT IT-09-9018

This appendix presents floor plan layouts, floor space data, architectural data, and operations data assembled for selected bus maintenance facilities. The floor plans are either based on as-built architectural drawings of each facility or the best drawings available. Space allocation data were scaled from the original drawings. It should be noted that the floor space summaries include only primary functional areas; minor areas and circulation are not shown. All other data were obtained through telephone interviews and personal interviews with knowledgeable officials from each transit system.

INDEX

SINGLE FACILITIES	MULTIPLE FACILITIES
AKRON	ALBANY - SCHENECTADY
ALBUQUERQUE	ALBANY - TROY
CHAPEL HILL	ALBANY - WATERVLIET
CHATTANOOGA	ATLANTA - BROWNS MILL
COLUMBUS	BOSTON
DES MOINES	BUFFALO
DULUTH	DENVER
EL PASO	DENVER - AURORA
FORT WRIGHT	DENVER - BOULDER
GALVESTON	DENVER - LONGMONT
JACKSONVILLE	PHOENIX - NORTH
LOUISVILLE	PHOENIX - SOUTH
MADISON	SEATTLE
OMAHA	ST. PAUL
PENSACOLA	WASHINGTON, D.C.
RALEIGH	
SCRANTON	
WILMINGTON	

AKRON / METRO REGIONAL TRANSIT AUTHORITY
AKRON, OHIO

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	353
Offices	5036
Conference Room	441
Other	1662
** TOTAL **	7492

TRANSPORTATION SPACE

	(sq. ft.)
Offices	458
Locker Room	0
Train Room	924
Training Room	823
Lunch Room	736
Radio,Dispatch	269
Fare Box Room	0
Storage	0
** TOTAL **	3829

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	10
Indoor Parking Spaces	98
Number of Axle Lifts	10
Number of Wheel Lifts	0
Number of Pits	0

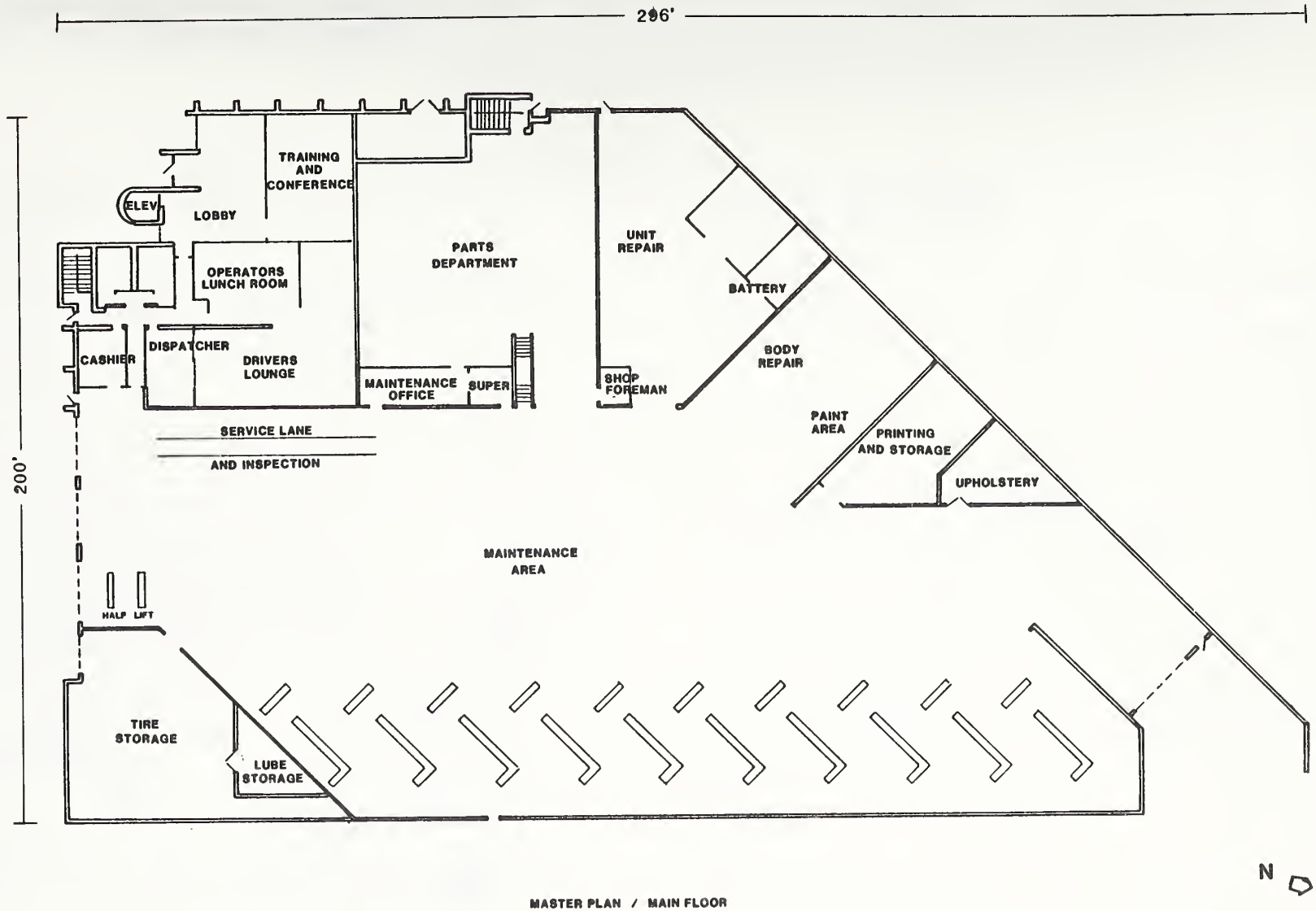
	(sq. ft.)
Offices	458
Locker Room	1587
Body Repair	0
Dynamometer Bay	0
General Repair	26710
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	9781
Storage	1499
Lunch Room	930
Paint Booth	999
Steam Bay	440
Overhaul	2382
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	240
Brake Repair	0
** TOTAL **	52658

OPERATIONAL DATA

Capacity	150
Fleet	129
Peak Buses	105
Base Buses	65
Annual Bus Miles	3,465,888
Annual Bus Hours	277,271

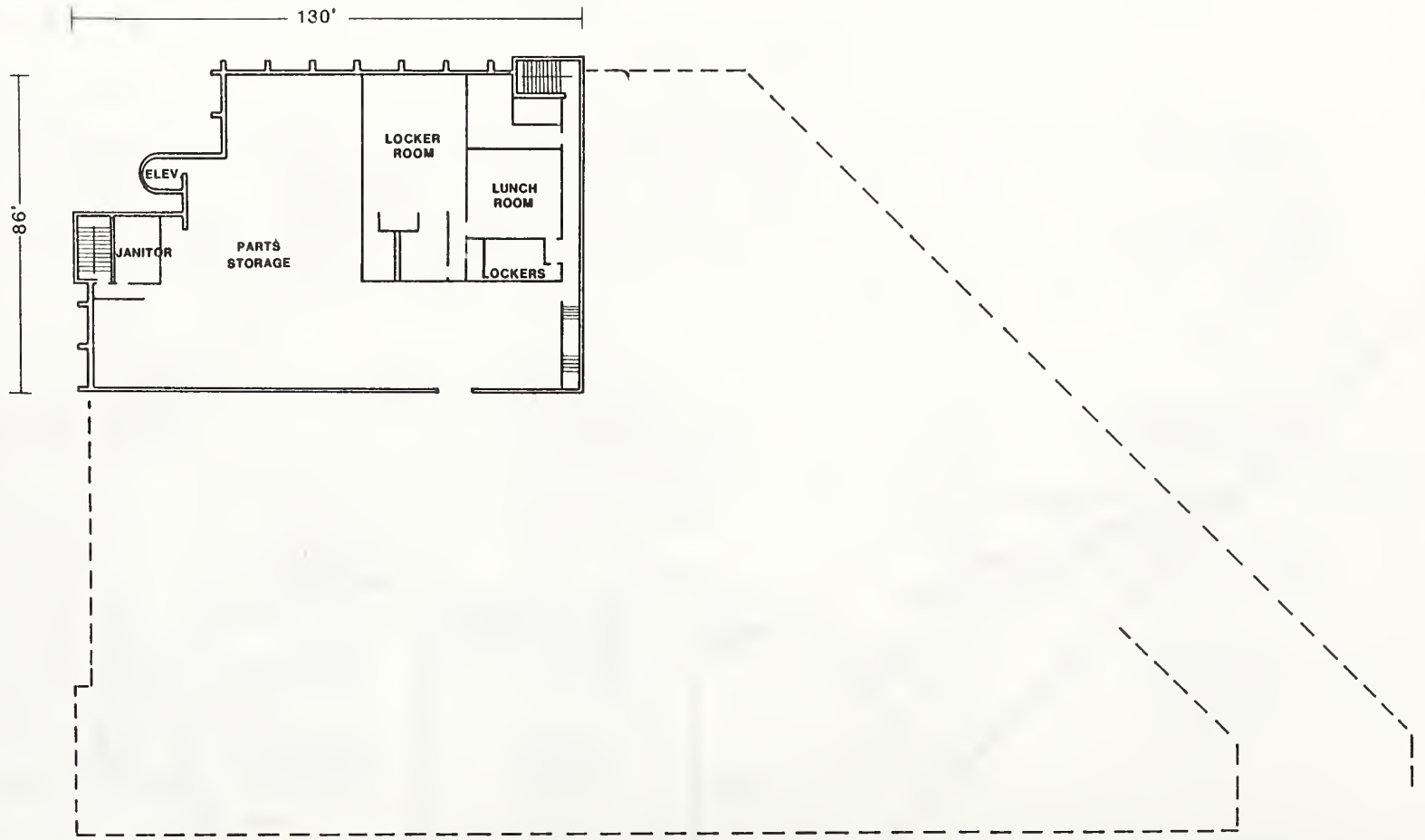
PERSONNEL DATA

Total	230
Administrative	34
Transportation	163
Drivers	163
Other	-1
Maintenance	33
Mechanics	21
Service	-1
Other	12



MASTER PLAN / MAIN FLOOR

AKRON / METRO REGIONAL TRANSIT AUTHORITY
MAINTENANCE AND OFFICE BUILDING
Architect: James J. Reinbolt, A.I.A.
Year Opened: 1981



SECOND FLOOR PLAN

AKRON / METRO REGIONAL TRANSIT AUTHORITY
MAINTENANCE AND OFFICE BUILDING

BUILDING SHELL

Structural Framing	Masonry & Steel Joists
Exterior Walls	Masonry with Brick Facing
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	22'-0"
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	16'-0"
Ceiling Height, Main Parts Level	8'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	10'-0"
Inspection and Running Repair Pit Depth	4'-6"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	Fluorescent
Bus Storage Area	Mercury Vapor
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Infrared Heaters
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

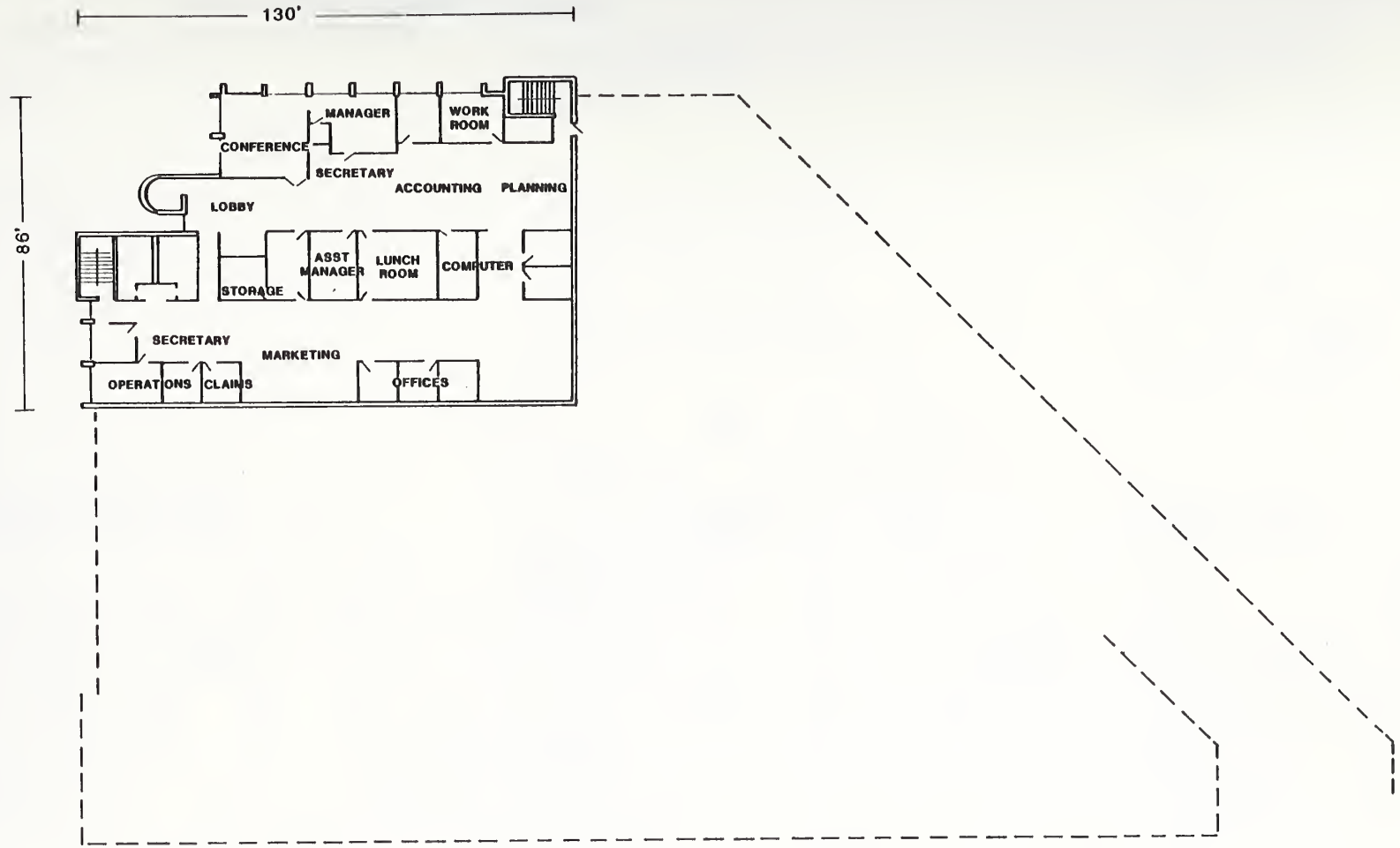
Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

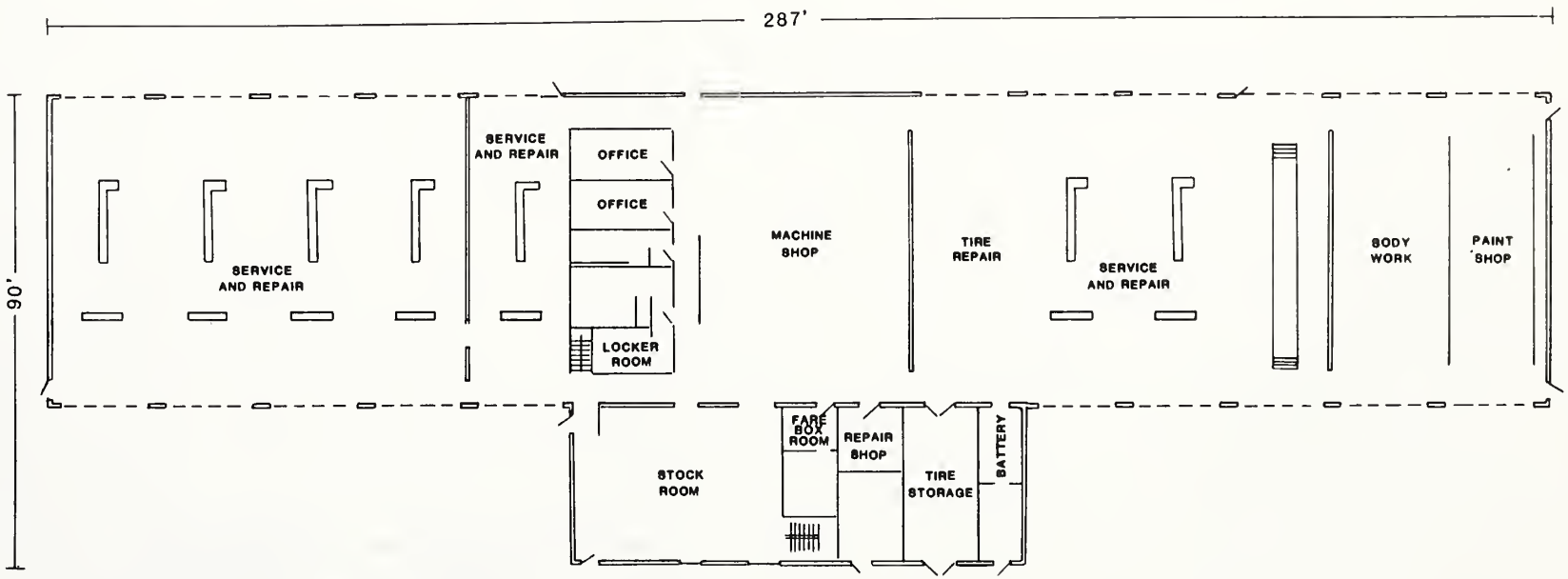
OTHER

Emergency Power Source	No
Security System	Card Controlled Access
Computer Energy Management	No
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Asphalt



THIRD FLOOR PLAN

AKRON / METRO REGIONAL TRANSIT AUTHORITY
MAINTENANCE AND OFFICE BUILDING



MASTER FLOOR PLAN / MAINTENANCE SHOP BUILDING

ALBUQUERQUE / CITY OF ALBUQUERQUE
TRANSIT SYSTEM MAINTENANCE TERMINAL
Architect: Michael Del Mastro, A.I.A.
Year Opened: 1983

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	80
Storage	0
** TOTAL **	80

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	11
Indoor Parking Spaces	74
Number of Axle Lifts	6
Number of Wheel Lifts	0
Number of Pits	2

	(sq. ft.)
Offices	380
Locker Room	180
Body Repair	0
Dynamometer Bay	0
General Repair	13320
Parts Cleaning	0
Injector Room	130
Brake Bay	0
Wheel Alignment	0
Parts Room	1170
Storage	144
Lunch Room	0
Paint Booth	1260
Steam Bay	0
Overhaul	163
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	126
Brake Repair	0
** TOTAL **	19109

OPERATIONAL DATA

Capacity	104
Fleet	107
Peak Buses	80
Base Buses	61
Annual Bus Miles	3,000,000
Annual Bus Hours	229,580

PERSONNEL DATA

Total	196
Administrative	8
Transportation	139
Drivers	139
Other	0
Maintenance	49
Mechanics	20
Service	15
Other	14

BUILDING SHELL

Structural Framing	Pre-Engineered Metal Building
Exterior Walls	Metal
Roof	Metal
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	25'-0"
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	16'-0"
Bus Garage Door Opening Width	16'-0"
Ceiling Height, Main Parts Level	8'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	10'-0"
Inspection and Running Repair Pit Depth	4'-9"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	High Pressure Sodium
Bus Storage Area	NA
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Infrared Heaters
Heat Source Fuel	Gas
Areas Cooled	Machine Shop, Parts, & Office Areas by Evaporative Cooling

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	No

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	No
Security System	Guards
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

CHAPEL HILL / TOWN OF CHAPEL HILL
CHAPEL HILL, NORTH CAROLINA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	596
Locker Room	326
Train Room	0
Training Room	217
Lunch Room	0
Radio,Dispatch	134
Fare Box Room	0
Storage	0
** TOTAL **	2007

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	4
Indoor Parking Spaces	0
Number of Axle Lifts	2
Number of Wheel Lifts	0
Number of Pits	0

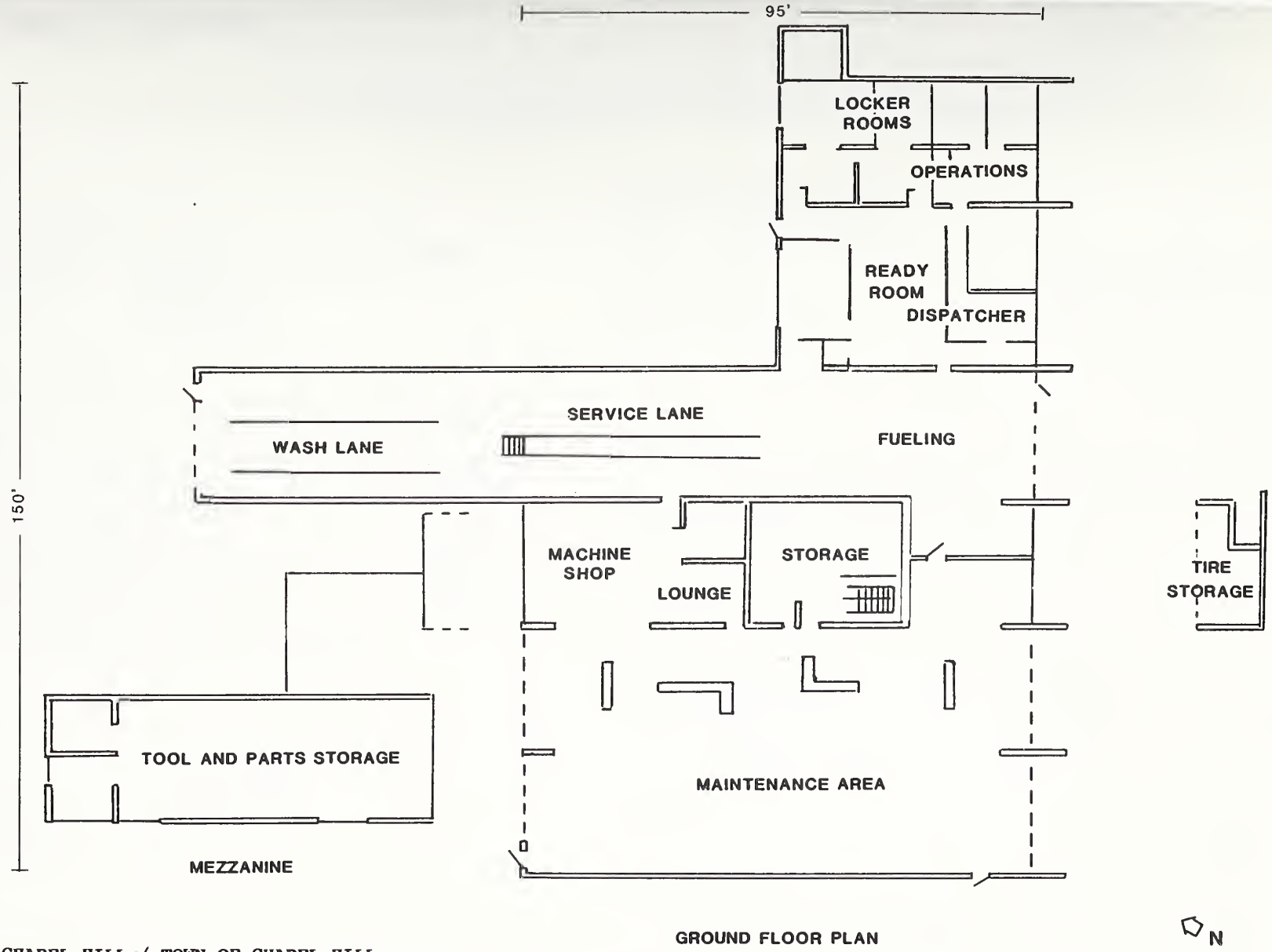
	(sq. ft.)
Offices	140
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	6215
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	1671
Storage	217
Lunch Room	124
Paint Booth	0
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	0
** TOTAL **	11012

OPERATIONAL DATA

Capacity	50
Fleet	48
Peak Buses	27
Base Buses	14
Annual Bus Miles	780,000
Annual Bus Hours	56,000

PERSONNEL DATA

Total	81
Administrative	0
Transportation	69
Drivers	60
Other	9
Maintenance	12
Mechanics	6
Service	4
Other	2



GROUND FLOOR PLAN

CHAPEL HILL / TOWN OF CHAPEL HILL
TRANSIT OPERATIONS AND MAINTENANCE FACILITY

Architect: Cogswell, Hausler Associates, P.A.
Year Opened: 1980

BUILDING SHELL

Structural Framing	Masonry & Structural Steel
Exterior Walls	Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	Varies
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	Split
Ceiling Height, Upper Parts Level	Split
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	4'-0"

LIGHTING

High Bay Area	Fluorescent
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	NA

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	Passive Solar
Heat Source	Infrared Radiant Heaters
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Solar and Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	No

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Ashpalt & Concrete

CHATTANOOGA / CHATTANOOGA AREA REGIONAL TRANSPORTATION AUTHORITY
CHATTANOOGA, TENNESEE

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	294
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	462
Storage	0
** TOTAL **	756

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	13
Indoor Parking Spaces	150
Number of Axle Lifts	8
Number of Wheel Lifts	0
Number of Pits	0

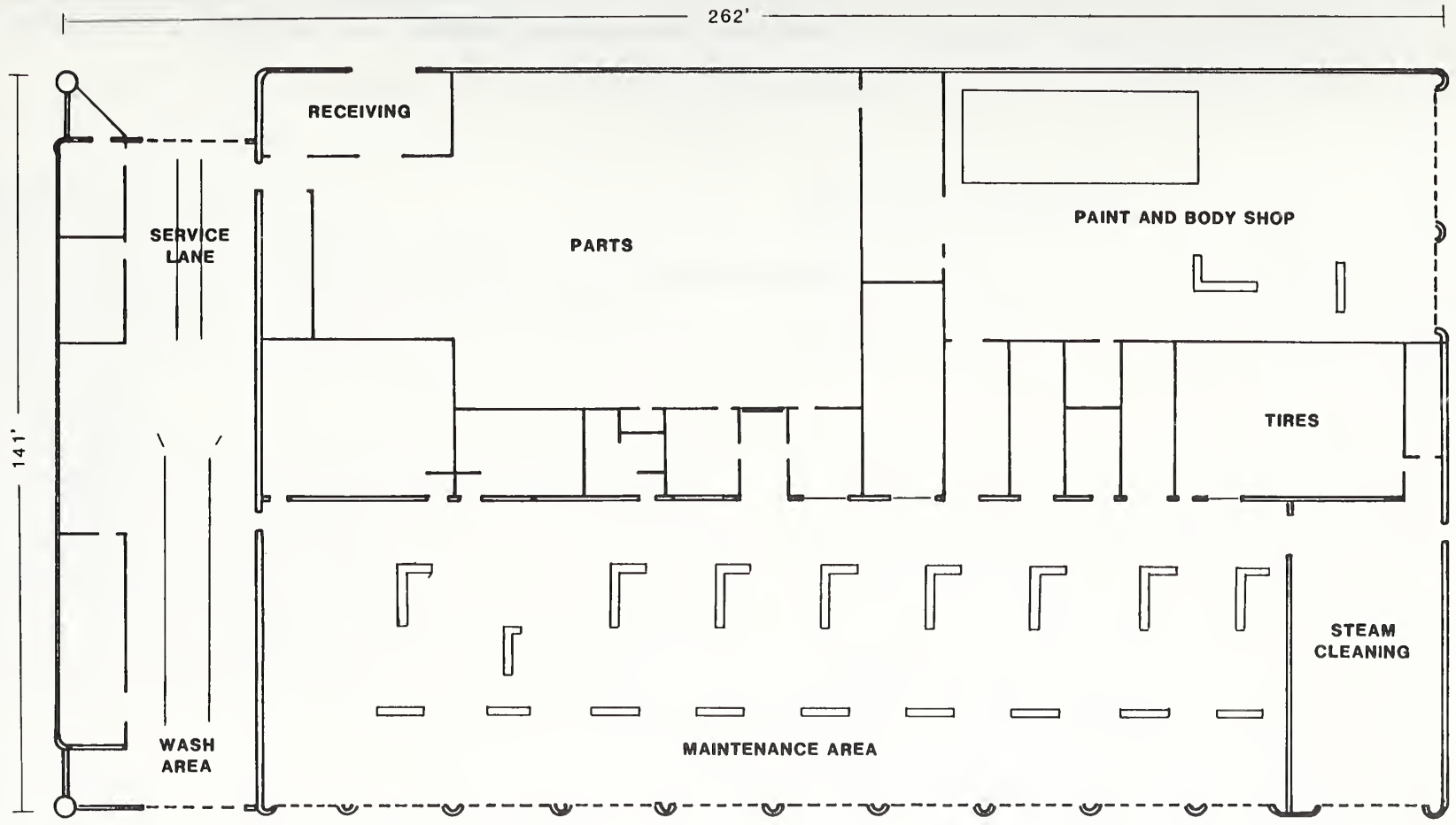
	(sq. ft.)
Offices	0
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	13378
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	0
Storage	9863
Lunch Room	0
Paint Booth	0
Steam Bay	1950
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	290
Brake Repair	0
** TOTAL **	35313

OPERATIONAL DATA

Capacity	100
Fleet	69
Peak Buses	42
Base Buses	17
Annual Bus Miles	1,600,000
Annual Bus Hours	100,000

PERSONNEL DATA

Total	101
Administrative	11
Transportation	65
Drivers	59
Other	6
Maintenance	25
Mechanics	18
Service	0
Other	7



MASTER FLOOR PLAN

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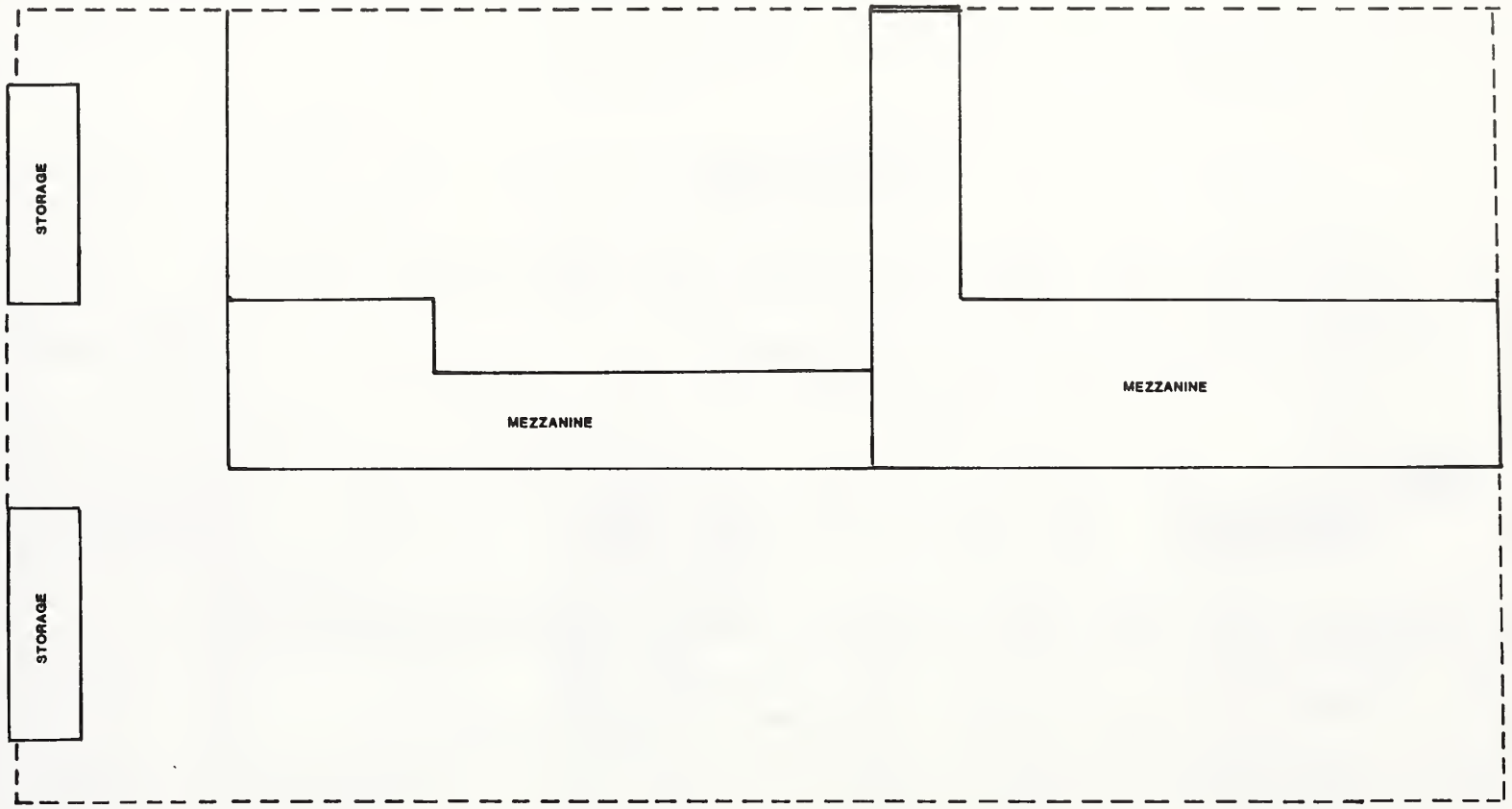
CHATTANOOGA / CHATTANOOGA AREA REGIONAL TRANSPORTATION AUTHORITY
Architect: Selmon T. Franklin Associates, Architects, Inc.
Year Opened: 1978



MEZZANINE FLOOR PLAN

CHATTANOOGA / CHATTANOOGA AREA REGIONAL TRANSPORTATION AUTHORITY

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Precast Concrete Panels
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	22'-3"
Ceiling Height Service Area	22'-3"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	16'-0"
Ceiling Height, Main Parts Level	22'-3"
Ceiling Height, Upper Parts Level	11'-0"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	Fluorescent
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Infrared Heaters
Heat Source Fuel	Gas
Areas Cooled	Lunch Room, Fare Box Room & Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Electricity
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	No
Heat Recovery	No

OTHER

Emergency Power Source	No
Security System	Closed Circuit TV & Guards
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

COLUMBUS / COTA BUS FACILITY
CENTRAL OHIO TRANSIT AUTHORITY
COLUMBUS, OHIO

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	26700
Conference Room	0
Other	0
** TOTAL **	26700

TRANSPORTATION SPACE

	(sq. ft.)
Offices	5850
Locker Room	0
Train Room	2400
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	8250

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	29
Indoor Parking Spaces	240
Number of Axle Lifts	26
Number of Wheel Lifts	0
Number of Pits	0

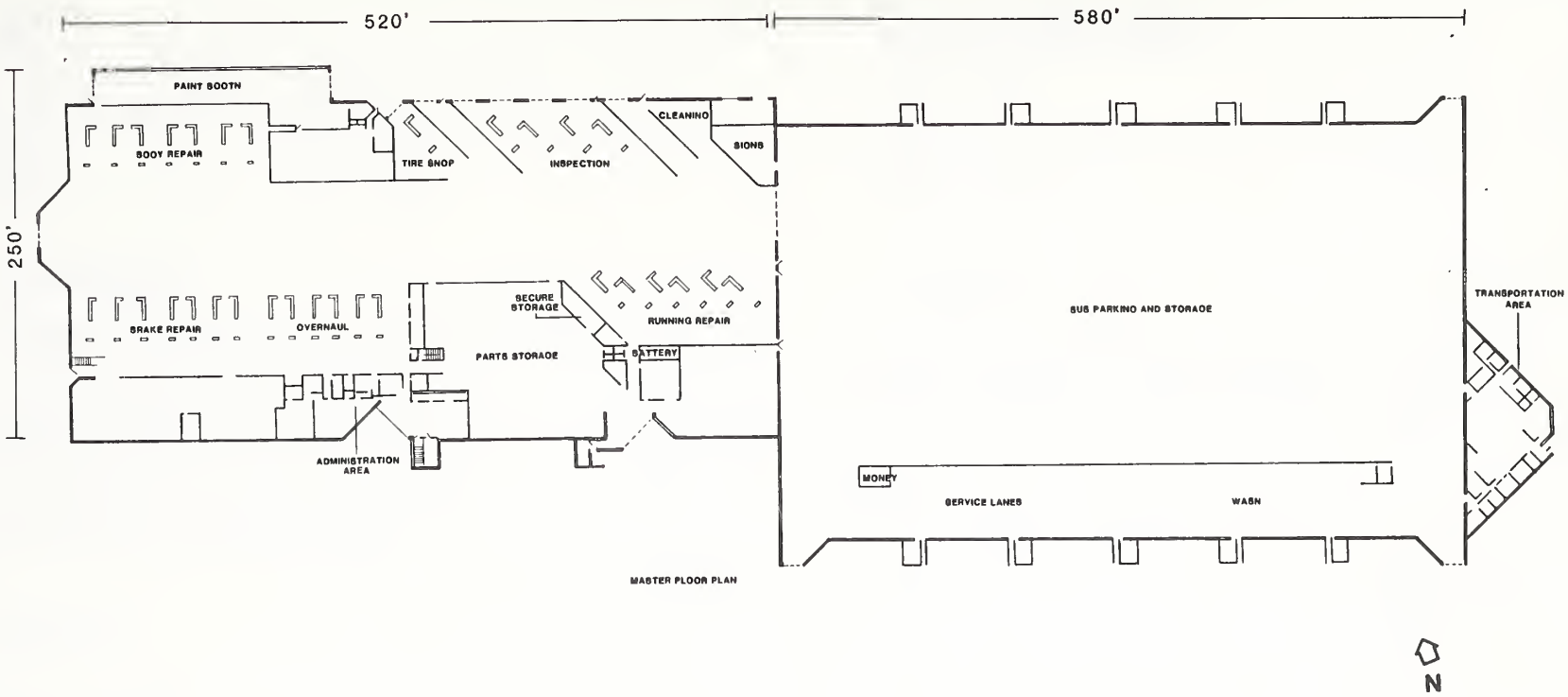
	(sq. ft.)
Offices	800
Locker Room	0
Body Repair	0
Dynamometer Bay	1500
General Repair	24800
Parts Cleaning	0
Injector Room	0
Brake Bay	7200
Wheel Alignment	0
Parts Room	0
Storage	25850
Lunch Room	0
Paint Booth	5575
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	300
Brake Repair	0
** TOTAL **	124275

OPERATIONAL DATA

Capacity	240
Fleet	322
Peak Buses	255
Base Buses	125
Annual Bus Miles	8,700,000
Annual Bus Hours	683,000

PERSONNEL DATA

Total	651
Administrative	93
Transportation	441
Drivers	428
Other	13
Maintenance	117
Mechanics	64
Service	28
Other	25



COLUMBUS / CENTRAL OHIO TRANSIT AUTHORITY
COTA BUS FACILITY

Architect: Kellam & Smith Architects, Planners, Inc.
Year Opened: 1980

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Concrete with Brick Facing
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	20'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	14'-0"
Ceiling Height, Main Parts Level	20'-0"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	10'-0"
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	NA
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	None

PLUMBING

Heat Source Fuel for Hot Water	Electricity
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Water Wash
Make Up Air Heated	No
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	Guards & Electric Surveillance
Computer Energy Management	No
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Asphalt with Some Concrete

DES MOINES / METROPOLITAN TRANSIT AUTHORITY
DES MOINES, IOWA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	6372
Conference Room	0
Other	0
** TOTAL **	6372

TRANSPORTATION SPACE

	(sq. ft.)
Offices	1575
Locker Room	0
Train Room	600
Training Room	1050
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	3225

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	17
Indoor Parking Spaces	100
Number of Axle Lifts	7
Number of Wheel Lifts	0
Number of Pits	0

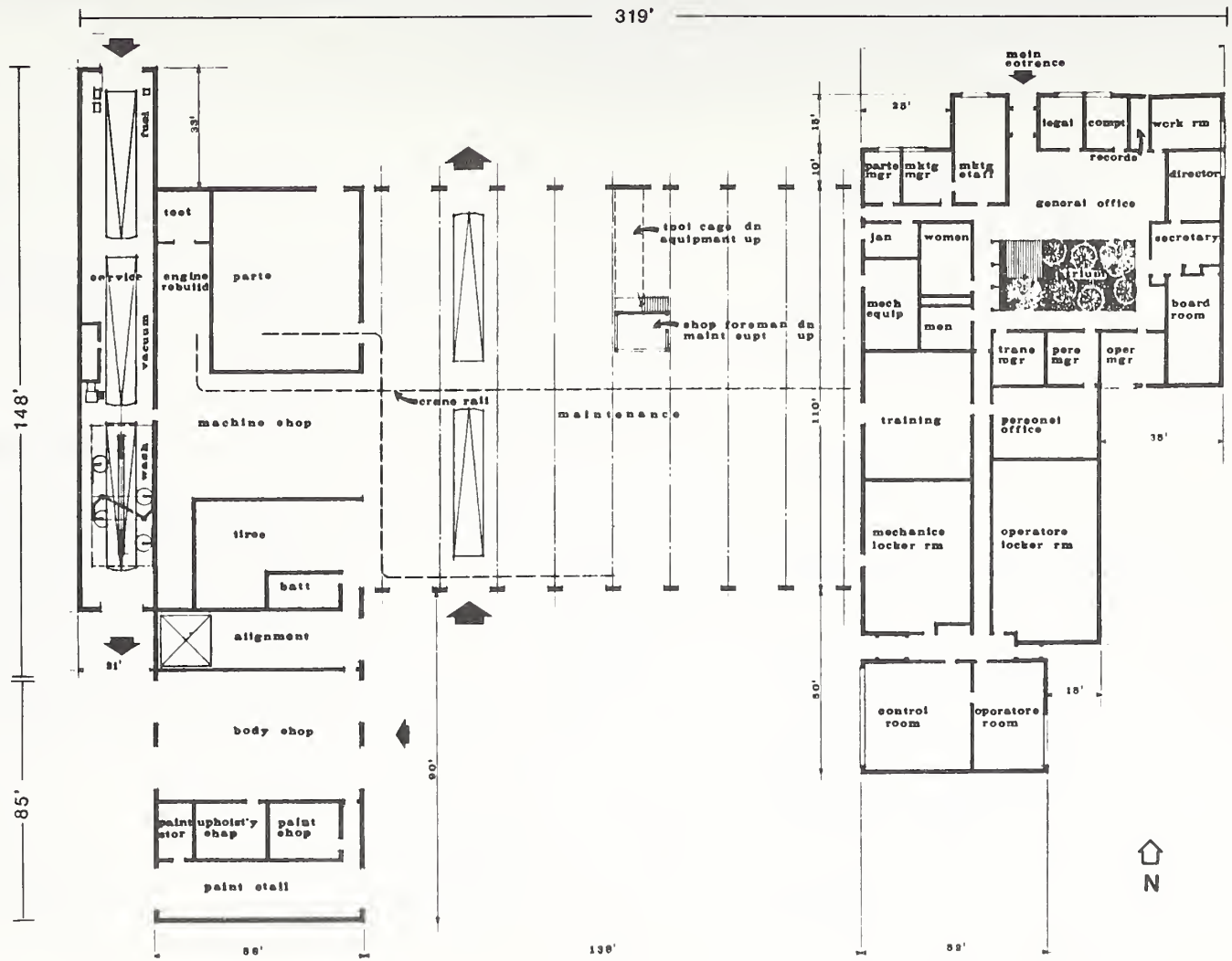
	(sq. ft.)
Offices	0
Locker Room	2880
Body Repair	0
Dynamometer Bay	0
General Repair	17385
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	928
Parts Room	2058
Storage	160
Lunch Room	0
Paint Booth	1248
Steam Bay	0
Overhaul	525
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	200
Brake Repair	0
** TOTAL **	34120

OPERATIONAL DATA

Capacity	100
Fleet	100
Peak Buses	72
Base Buses	33
Annual Bus Miles	2,100,000
Annual Bus Hours	

PERSONNEL DATA

Total	146
Administrative	2
Transportation	116
Drivers	105
Other	11
Maintenance	28
Mechanics	18
Service	6
Other	4



DES MOINES / METROPOLITAN TRANSIT AUTHORITY
ADMINISTRATIVE AND MAINTENANCE FACILITY

Architect: Lynch, Payne, Champion, Bernabe, Inc.
Year Opened: 1978

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Precast Concrete Panels
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	16'-0"
Ceiling Height Service Area	16'-0"
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	12'-0"
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Low Pressure Sodium
Low Bay Area	Low Pressure Sodium
Bus Storage Area	Low Pressure Sodium
Exterior Areas	Low Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas/Oil/Waste Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	Yes

OTHER

Emergency Power Source	Yes
Security System	Closed Circuit TV & Guards
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Concrete

DULUTH / DTA OPERATING CENTER
DULUTH TRANSIT AUTHORITY
DULUTH, MINNESOTA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	350
Offices	3809
Conference Room	0
Other	1476
** TOTAL **	5635

TRANSPORTATION SPACE

	(sq. ft.)
Offices	120
Locker Room	360
Train Room	144
Training Room	800
Lunch Room	1147
Radio,Dispatch	512
Fare Box Room	174
Storage	0
** TOTAL **	4407

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	14
Indoor Parking Spaces	140
Number of Axle Lifts	7
Number of Wheel Lifts	0
Number of Pits	0

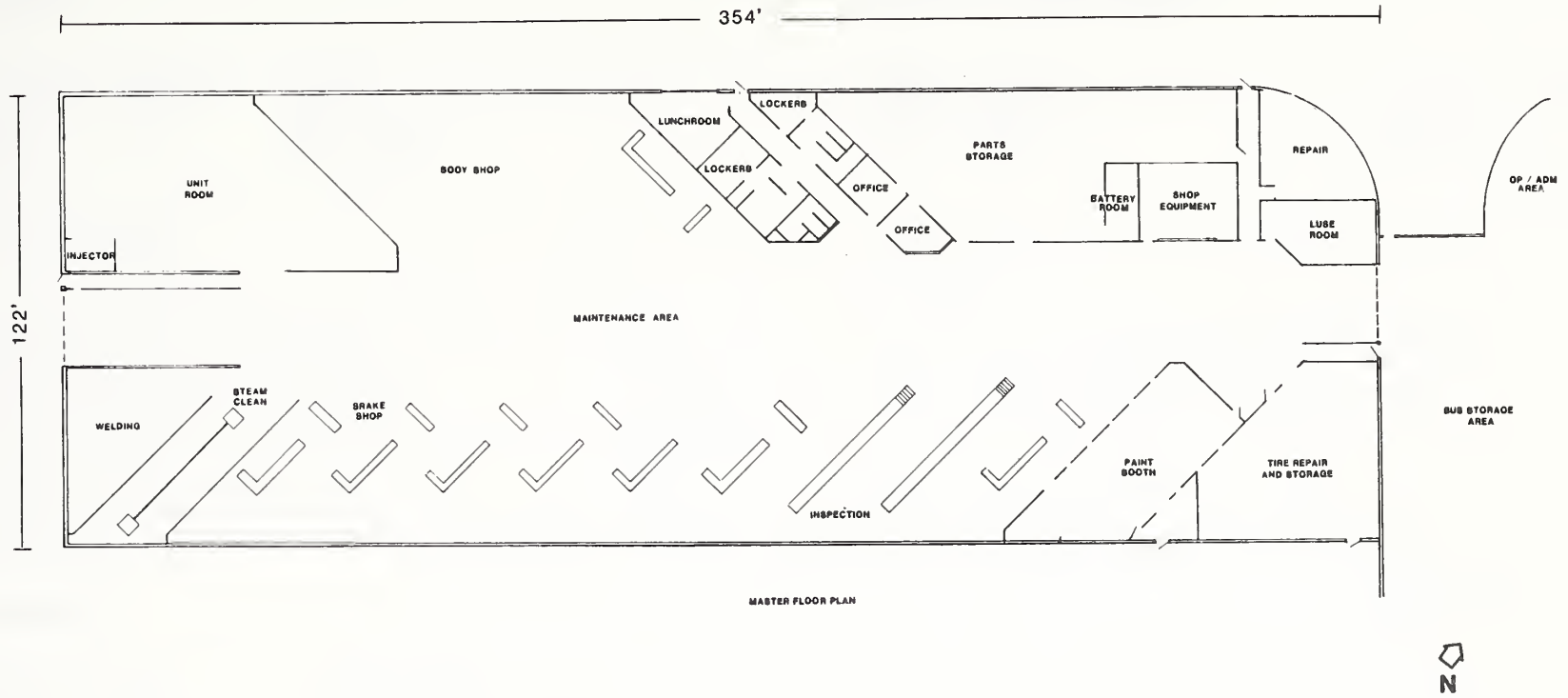
	(sq. ft.)
Offices	384
Locker Room	896
Body Repair	0
Dynamometer Bay	0
General Repair	9740
Parts Cleaning	0
Injector Room	104
Brake Bay	0
Wheel Alignment	0
Parts Room	3005
Storage	594
Lunch Room	368
Paint Booth	2304
Steam Bay	1400
Overhaul	3038
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	160
Brake Repair	1400
** TOTAL **	37475

OPERATIONAL DATA

Capacity	150
Fleet	95
Peak Buses	77
Base Buses	25
Annual Bus Miles	2,083,301
Annual Bus Hours	159,163

PERSONNEL DATA

Total	166
Administrative	18
Transportation	118
Drivers	108
Other	10
Maintenance	30
Mechanics	22
Service	5
Other	3



MASTER FLOOR PLAN

DULUTH / DULUTH TRANSIT AUTHORITY
DTA OPERATING CENTER
Architect: Thomas and Vecchi, A.I.A.
Year Opened: 1981

BUILDING SHELL

Structural Framing	Masonry & Structural Steel
Exterior Walls	Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	NA
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	16'-0"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	Fluorescent
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas/Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas/Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

EL PASO / PUBLIC TRANSIT ADMINISTRATION
EL PASO, TEXAS

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	0

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	16
Indoor Parking Spaces	0
Number of Axle Lifts	11
Number of Wheel Lifts	2
Number of Pits	1

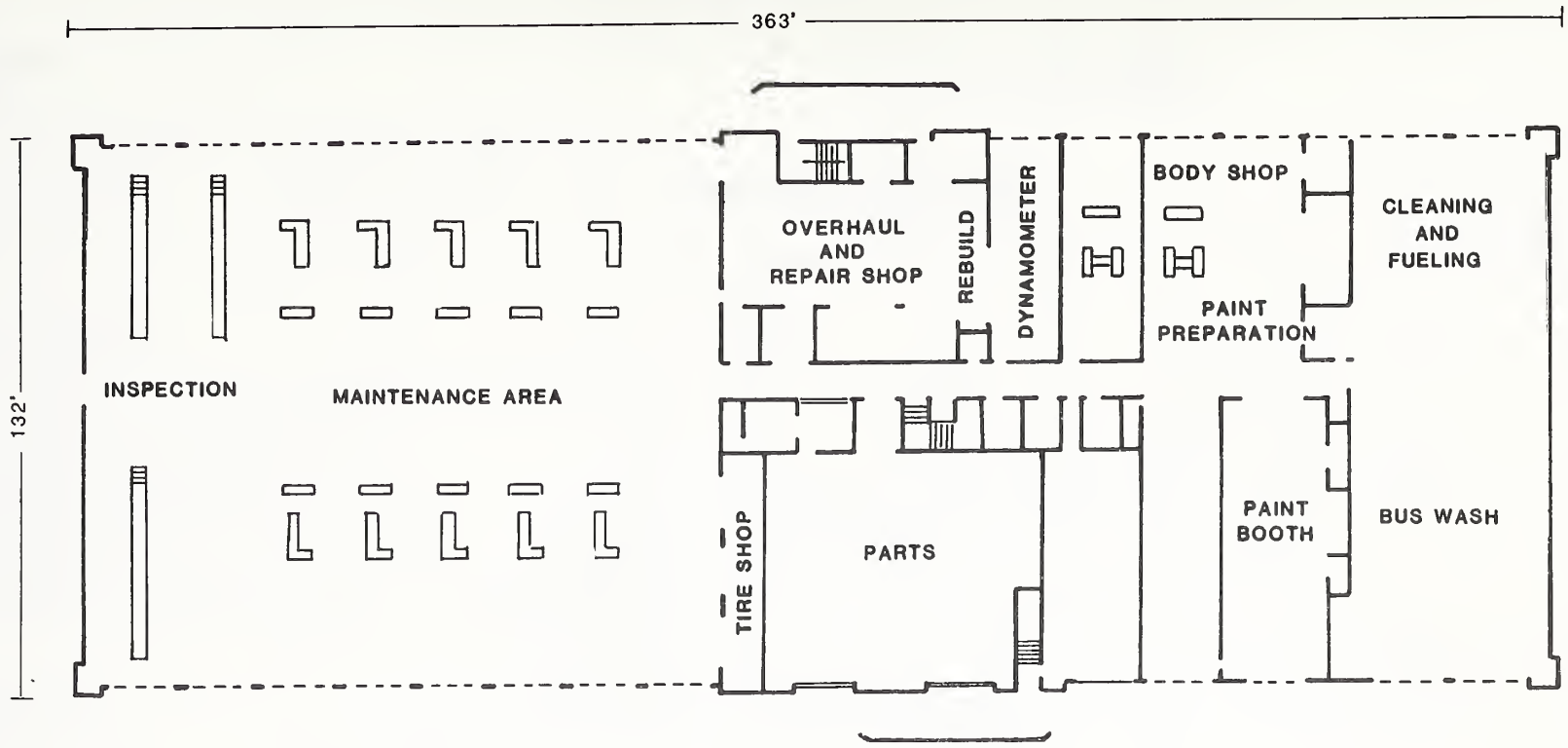
	(sq. ft.)
Offices	598
Locker Room	1377
Body Repair	0
Dynamometer Bay	1229
General Repair	21216
Parts Cleaning	169
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	7079
Storage	557
Lunch Room	1633
Paint Booth	2277
Steam Bay	1060
Overhaul	1940
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	256
Brake Repair	0
** TOTAL **	52262

OPERATIONAL DATA

Capacity	261
Fleet	150
Peak Buses	79
Base Buses	45
Annual Bus Miles	3,991,826
Annual Bus Hours	291,800

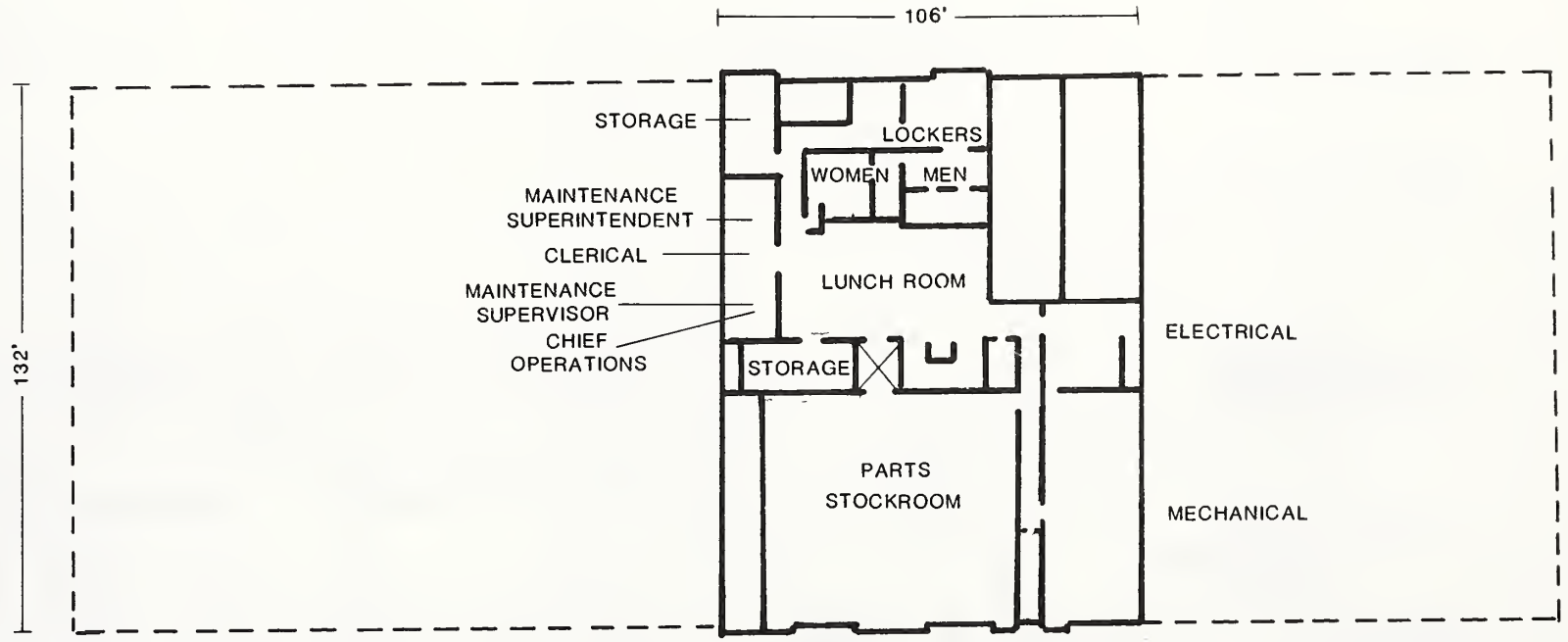
PERSONNEL DATA

Total	312
Administrative	15
Transportation	228
Drivers	211
Other	17
Maintenance	69
Mechanics	43
Service	23
Other	3



MASTER FLOOR PLAN

EL PASO / PUBLIC TRANSIT ADMINISTRATION
ADMINISTRATION/OPERATIONS/MAINTENANCE FACILITY
Architect: Garland and Hilles, Architects
Year Opened: 1982



MEZZANINE FLOOR PLAN

EL PASO / PUBLIC TRANSIT ADMINISTRATION
ADMINISTRATION/OPERATIONS/MAINTENANCE FACILITY

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Precast Concrete Panels
Roof	Concrete Plank
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	18'-0"
Bus Garage Door Opening Width	10'-10"
Ceiling Height, Main Parts Level	NA
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	10'-0"
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	Low Pressure Sodium
Low Bay Area	NA
Bus Storage Area	NA
Exterior Areas	Low Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	Entire Building by Evaporative Cooling

PLUMBING

Heat Source Fuel for Hot Water	NA
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	Card Controlled Access & Closed Circuit TV
Computer Energy Management	Yes
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Concrete

FORT WRIGHT / TRANSIT AUTHORITY OF NORTHERN KENTUCKY
FORT WRIGHT, KENTUCKY

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	380
Offices	3199
Conference Room	416
Other	1279
** TOTAL **	5274

TRANSPORTATION SPACE

	(sq. ft.)
Offices	1706
Locker Room	760
Train Room	304
Training Room	336
Lunch Room	468
Radio,Dispatch	832
Fare Box Room	255
Storage	0
** TOTAL **	6476

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	18
Indoor Parking Spaces	160
Number of Axle Lifts	14
Number of Wheel Lifts	1
Number of Pits	2

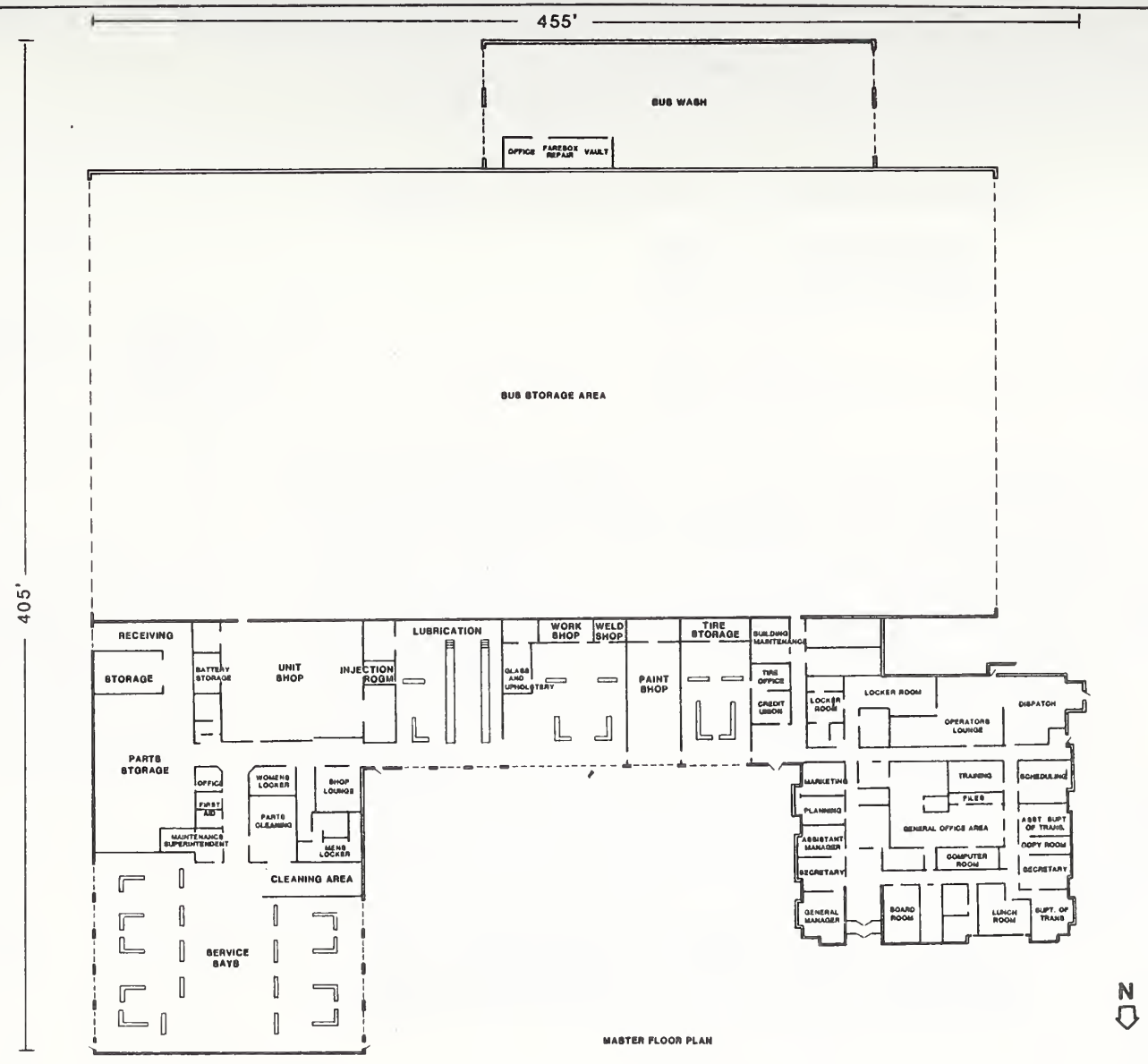
	(sq. ft.)
Offices	569
Locker Room	1181
Body Repair	0
Dynamometer Bay	0
General Repair	12692
Parts Cleaning	696
Injector Room	130
Brake Bay	0
Wheel Alignment	0
Parts Room	6415
Storage	1578
Lunch Room	0
Paint Booth	1173
Steam Bay	672
Overhaul	3538
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	216
Brake Repair	0
** TOTAL **	41515

OPERATIONAL DATA

Capacity	160
Fleet	96
Peak Buses	83
Base Buses	27
Annual Bus Miles	3,000,000
Annual Bus Hours	205,000

PERSONNEL DATA

Total	195
Administrative	29
Transportation	127
Drivers	116
Other	11
Maintenance	39
Mechanics	15
Service	25
Other	-1



MASTER FLOOR PLAN

FORT WRIGHT / TRANSIT AUTHORITY OF NORTHERN KENTUCKY
GARAGE AND MAINTENANCE FACILITY

Architect: Carl C. Bankemper & Associates
Year Opened: 1982

Maintenance Reliability Improves Dramatically After TANK Move to New, Efficient Facility

NEWPORT, KY.—Since moving to its new maintenance facility in Ft. Wright, the Transit Authority of Northern Kentucky has seen an improvement in the reliability of the work performed by the maintenance department personnel. Among the more notable developments since moving to the new building are:

- a 35% decline in the number of road repair calls;
- the average fuel economy for the fleet of buses has increased 9.2%;
- necessary overtime for mechanics has been reduced by 32%; and
- the average miles per quart of oil uses has increased by 22%.

According to Paul Clayton, TANK maintenance manager, "The better equipment and facilities in the new building allow our mechanics and service personnel to use their expertise to keep our fleet running in top condition. Unlike the former TANK building in Newport, the new building was constructed to provide efficient maintenance facilities for TANK's modern transit buses."

Clayton also credits the new computer system that allows TANK to better use an improved preventative maintenance program. Clayton said that strict records are kept on the amount of fuel, oil, and other fluids each bus uses each day. The computer information allows TANK to detect a small problem and prevent it from becoming a large and expensive problem.

TANK General Manager Stephen Morris said, "It is easy to see that since the move there has been both increased reliability and economy. It is gratifying to see all of the efforts of the board of directors and fiscal courts begin to pay off the people we serve."

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BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	17'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	10'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	12'-0"
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	Incandescent
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	Mercury - Vapor

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	No

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filters
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	Closed Circuit TV
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Concrete

GALVESTON / CITY OF GALVESTON
GALVESTON, TEXAS

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	780
Conference Room	0
Other	414
** TOTAL **	1194

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	276
Training Room	368
Lunch Room	0
Radio,Dispatch	169
Fare Box Room	183
Storage	0
** TOTAL **	1208

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	4
Indoor Parking Spaces	0
Number of Axle Lifts	0
Number of Wheel Lifts	1
Number of Pits	1

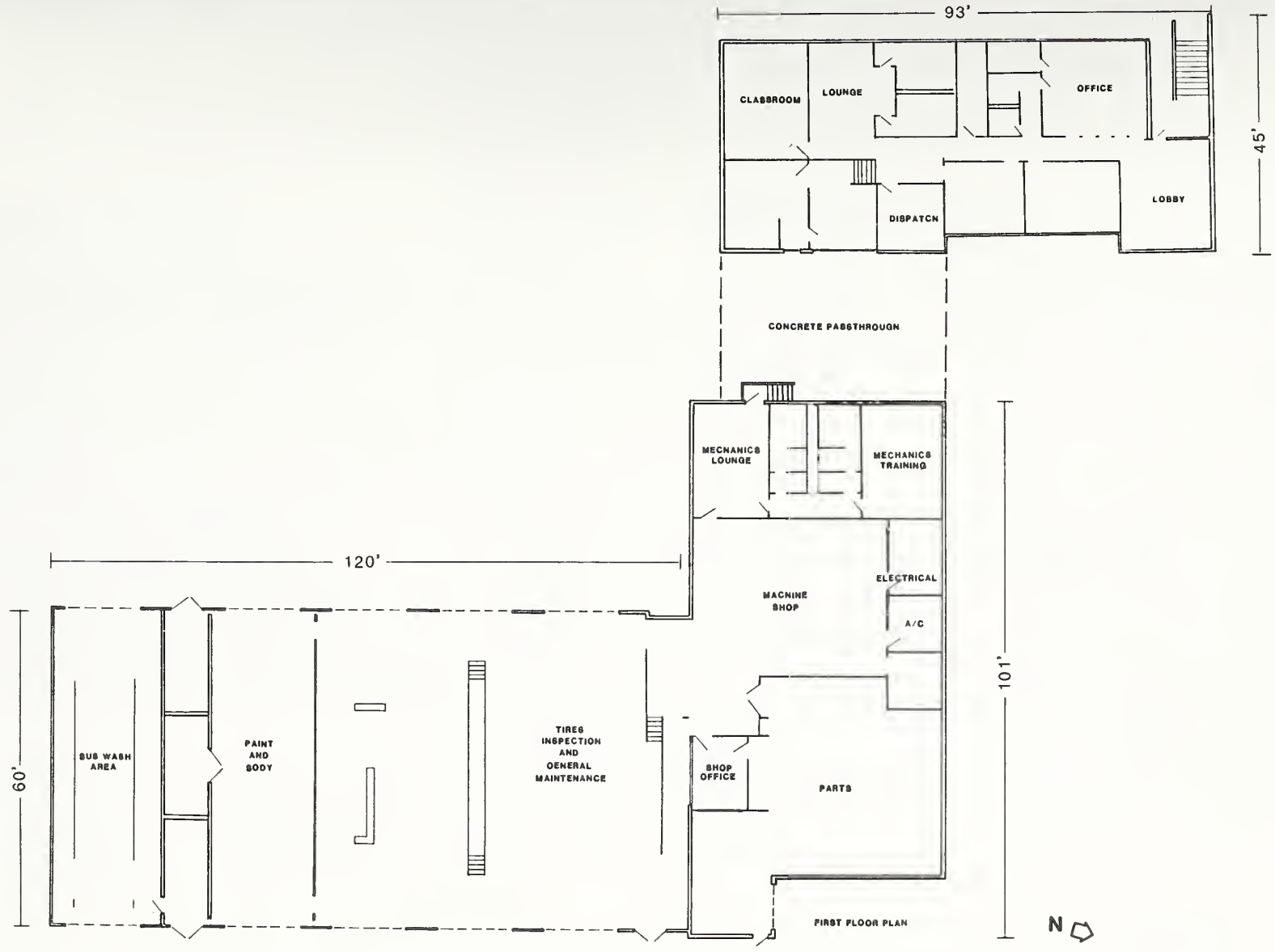
	(sq. ft.)
Offices	143
Locker Room	128
Body Repair	0
Dynamometer Bay	0
General Repair	5335
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	1581
Storage	152
Lunch Room	0
Paint Booth	0
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	100
Brake Repair	0
** TOTAL **	10972

OPERATIONAL DATA

Capacity	25
Fleet	15
Peak Buses	10
Base Buses	9
Annual Bus Miles	435,676
Annual Bus Hours	29,000

PERSONNEL DATA

Total	32
Administrative	4
Transportation	20
Drivers	19
Other	1
Maintenance	8
Mechanics	4
Service	2
Other	2



GALVESTON / CITY OF GALVESTON
TRANSIT BUS MAINTENANCE FACILITY

Architect: Rapp, Fash, Sundin, Inc.,
Associates and Planners, A.I.A.

Year Opened: 1982

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Metal Panels
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	NA
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	16'-0"
Bus Garage Door Opening Width	14'-0"
Ceiling Height, Main Parts Level	NA
Ceiling Height, Upper Parts Level	8'-0"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	4'-0"

LIGHTING

High Bay Area	Incandescent
Low Bay Area	NA
Bus Storage Area	Fluorescent
Exterior Areas	Metal Halide

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Not Heated
Heat Source Fuel	NA
Areas Cooled	None

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	No
Cleaning Method	NA
Make Up Air Heated	No
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	Guards
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

JACKSONVILLE / JACKSONVILLE TRANSPORTATION AUTHORITY
JACKSONVILLE, FLORIDA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	0

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	75
Indoor Parking Spaces	0
Number of Axle Lifts	25
Number of Wheel Lifts	4
Number of Pits	5

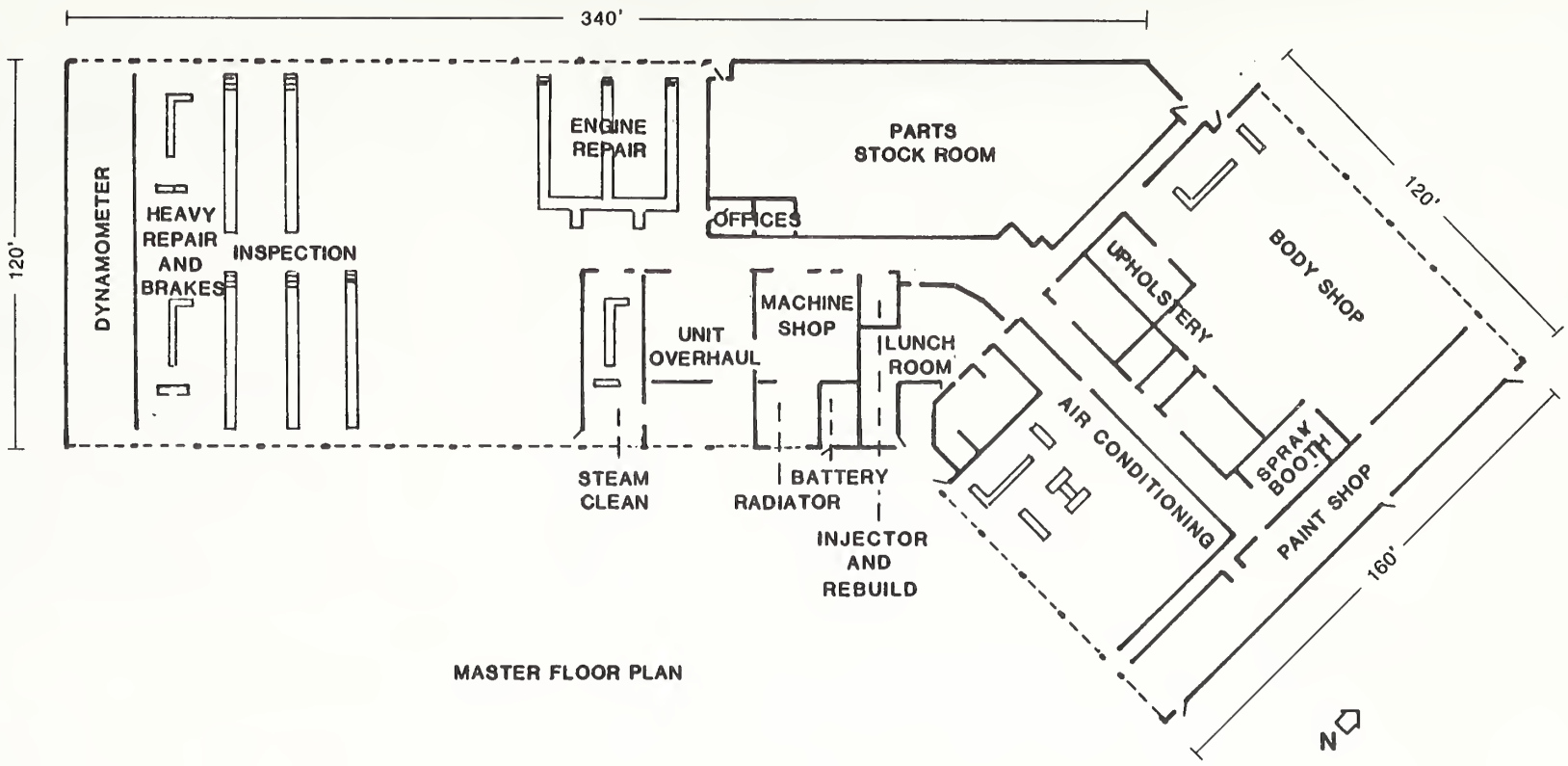
	(sq. ft.)
Offices	570
Locker Room	916
Body Repair	0
Dynamometer Bay	2200
General Repair	10320
Parts Cleaning	660
Injector Room	150
Brake Bay	0
Wheel Alignment	0
Parts Room	5730
Storage	0
Lunch Room	1225
Paint Booth	3700
Steam Bay	1000
Overhaul	945
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	200
Brake Repair	2300
** TOTAL **	43594

OPERATIONAL DATA

Capacity	300
Fleet	267
Peak Buses	165
Base Buses	60
Annual Bus Miles	3,000,000
Annual Bus Hours	-1

PERSONNEL DATA

Total	48
Administrative	0
Transportation	0
Drivers	0
Other	0
Maintenance	-1
Mechanics	0
Service	48
Other	-1



MASTER FLOOR PLAN

JACKSONVILLE / JACKSONVILLE TRANSPORTATION AUTHORITY
JTA MAINTENANCE BUILDING

Architect: Crowder, Hammack, Nicolaides & Willis, Inc.
Daniel, Mann, Johnson & Mendenhall

Year Opened: 1981

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Masonry
Roof	NA
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	25'-0"
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	10'-0"
Ceiling Height, Main Parts Level	9'-0"
Ceiling Height, Upper Parts Level	12'-0"
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	Fluorescent
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Electric Resistance
Heat Source Fuel	Electricity
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	No
Heat Recovery	NA

OTHER

Emergency Power Source	Yes
Security System	Guards
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt with Concrete Aprons

LOUISVILLE / OPERATING, MAINTENANCE, ADMINISTRATION AND STORAGE FACILITY
TRANSIT AUTHORITY OF RIVER CITY
LOUISVILLE, KENTUCKY

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	1190
Locker Room	1023
Train Room	1120
Training Room	0
Lunch Room	533
Radio,Dispatch	1096
Fare Box Room	0
Storage	360
** TOTAL **	8499

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	7
Indoor Parking Spaces	248
Number of Axle Lifts	8
Number of Wheel Lifts	0
Number of Pits	0

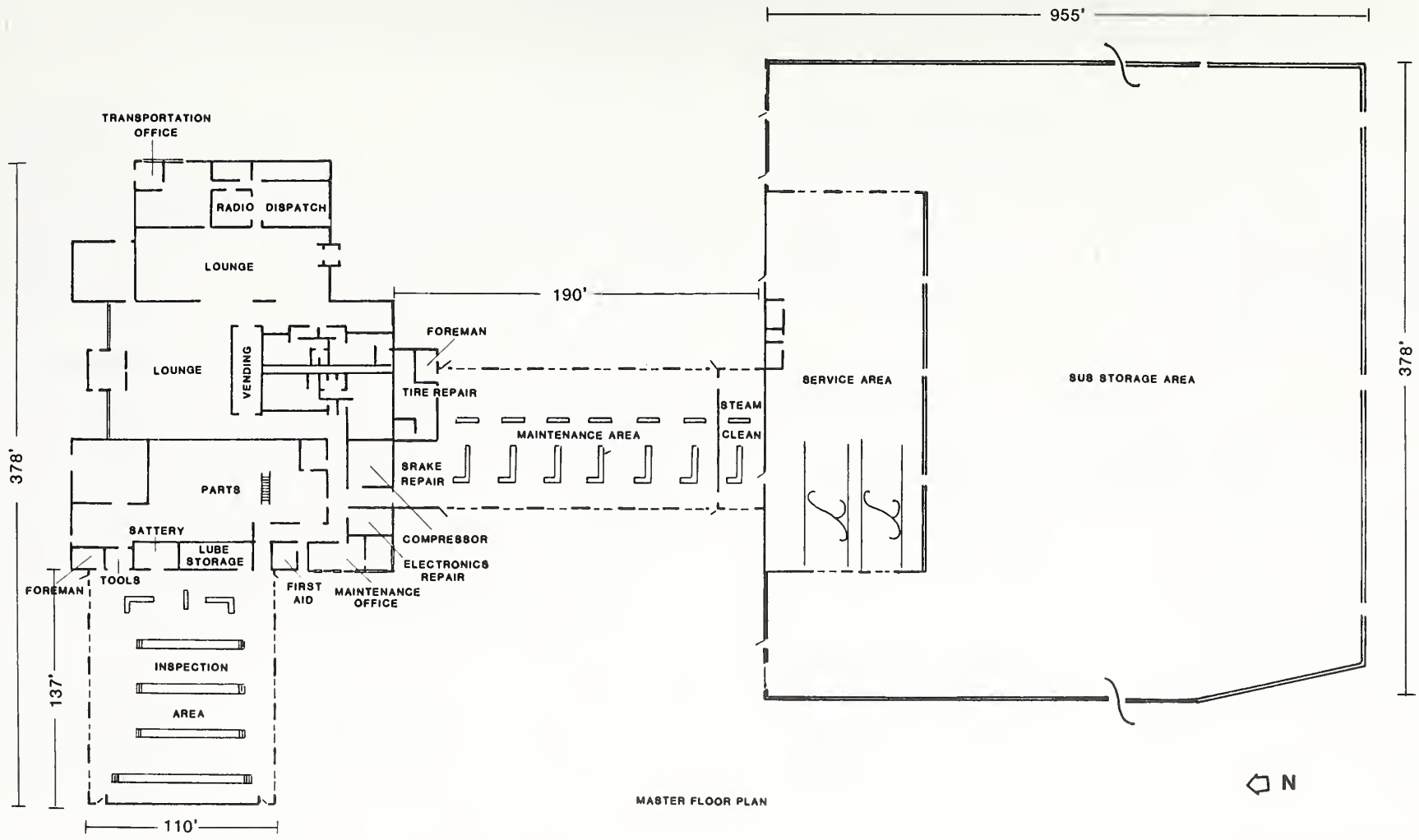
	(sq. ft.)
Offices	1028
Locker Room	1240
Body Repair	0
Dynamometer Bay	0
General Repair	8382
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	3289
Storage	1171
Lunch Room	0
Paint Booth	0
Steam Bay	1386
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	260
Brake Repair	630
** TOTAL **	42568

OPERATIONAL DATA

Capacity	248
Fleet	211
Peak Buses	168
Base Buses	59
Annual Bus Miles	-1
Annual Bus Hours	-1

PERSONNEL DATA

Total	346
Administrative	3
Transportation	287
Drivers	284
Other	3
Maintenance	56
Mechanics	27
Service	8
Other	21



LOUISVILLE / TRANSIT AUTHORITY OF RIVER CITY
OPERATING, MAINTENANCE, ADMINISTRATION AND STORAGE FACILITY

Architect: Luckett & Farley, Architects & Engineers
Year Opened: 1979

BUILDING SHELL

Structural Framing	Structural Steel & Masonry
Exterior Walls	Masonry w/Brick & Precast Concrete
Roof	Metal Deck Panels
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	20'-0"
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	Metal Halide

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source -	Electric Heaters in Shop, Hot
Heat Source Fuel	Water in Offices
Areas Cooled	Electricity and Gas
	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Electricity
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	Yes
Security System	Guards,Alarm System
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Concrete & Ashpalt

MADISON / MADISON METRO
MADISON, WISCONSIN

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	175
Offices	1700
Conference Room	200
Other	140
** TOTAL **	2215

TRANSPORTATION SPACE

	(sq. ft.)
Offices	470
Locker Room	0
Train Room	2830
Training Room	0
Lunch Room	0
Radio,Dispatch	840
Fare Box Room	0
Storage	0
** TOTAL **	4140

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	8
Indoor Parking Spaces	196
Number of Axle Lifts	8
Number of Wheel Lifts	0
Number of Pits	0

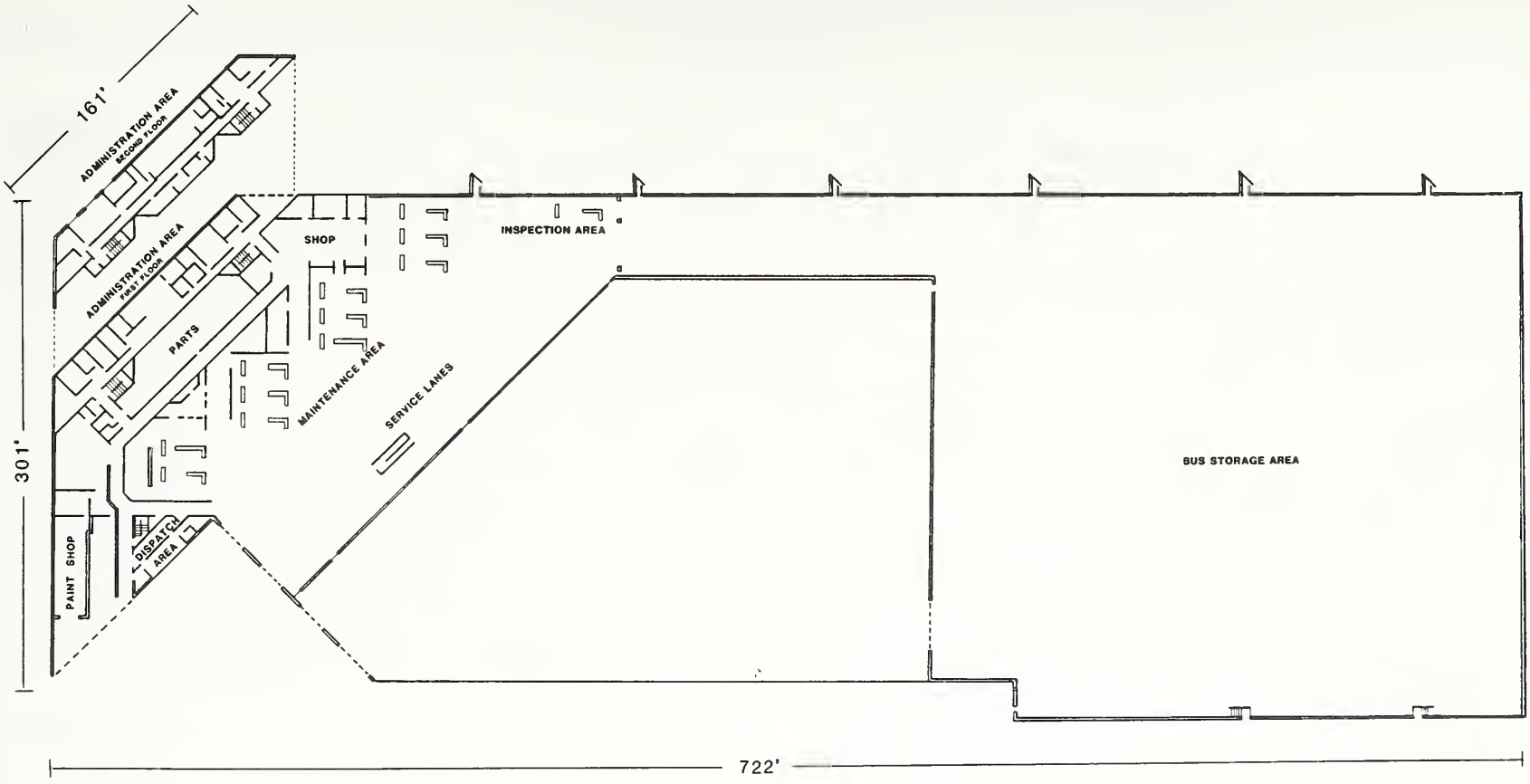
	(sq. ft.)
Offices	570
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	0
Parts Cleaning	250
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	3000
Storage	1700
Lunch Room	0
Paint Booth	1300
Steam Bay	0
Overhaul	3000
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	200
Brake Repair	0
** TOTAL **	86400

OPERATIONAL DATA

Capacity	196
Fleet	187
Peak Buses	141
Base Buses	92
Annual Bus Miles	4,977,696
Annual Bus Hours	354,118

PERSONNEL DATA

Total	303
Administrative	6
Transportation	226
Drivers	217
Other	9
Maintenance	71
Mechanics	35
Service	14
Other	22



MADISON / MADISON METRO
OPERATING GARAGE
Architect: Bowen Kanazawa Partnership
Year Opened: 1981

BUILDING SHELL

Structural Framing	Pre-Engineered Metal Building
Exterior Walls	Steel Panels
Roof	Steel Panels
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	15'-8"
Ceiling Height Service Area	15'-8"
Bus Garage Door Opening Height	11'-3"
Bus Garage Door Opening Width	22'-0"
Ceiling Height, Main Parts Level	7'-5"
Ceiling Height, Upper Parts Level	7'-4"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Fluorescent
Low Bay Area	NA
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas/Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	No

PAINTING FACILITIES

	Yes
Exhaust Air Cleaned	Dry Filter
Cleaning Method	No
Make Up Air Heated	No
Heat Recovery	

OTHER

Emergency Power Source	Yes
Security System	Alarm for Vault
Computer Energy Management	No
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Asphalt with Concrete Pads

OMAHA / THE TRANSIT AUTHORITY CITY OF OMAHA
OMAHA, NEBRASKA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	476
Offices	11936
Conference Room	1606
Other	8451
** TOTAL **	22469

TRANSPORTATION SPACE

	(sq. ft.)
Offices	3770
Locker Room	0
Train Room	1199
Training Room	132
Lunch Room	930
Radio,Dispatch	1118
Fare Box Room	103
Storage	1393
** TOTAL **	15648

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	28
Indoor Parking Spaces	250
Number of Axle Lifts	15
Number of Wheel Lifts	0
Number of Pits	3

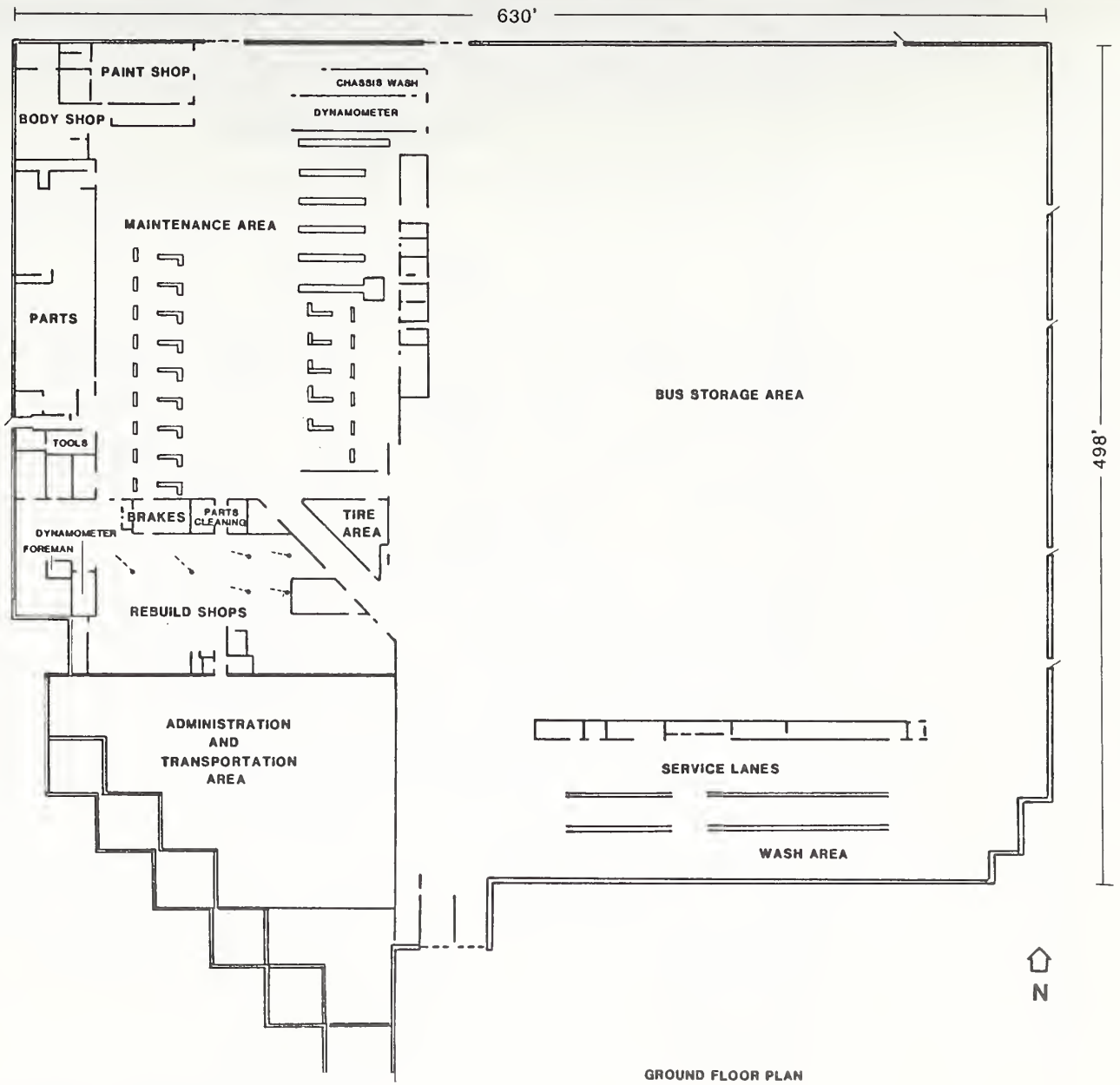
	(sq. ft.)
Offices	1499
Locker Room	1943
Body Repair	0
Dynamometer Bay	1947
General Repair	14560
Parts Cleaning	825
Injector Room	423
Brake Bay	0
Wheel Alignment	0
Parts Room	18009
Storage	4273
Lunch Room	966
Paint Booth	2852
Steam Bay	945
Overhaul	2560
Fare Box Repair	306
Tire Bay	0
Machine Shop	0
Battery Room	528
Brake Repair	608
** TOTAL **	89080

OPERATIONAL DATA

Capacity	250
Fleet	197
Peak Buses	170
Base Buses	90
Annual Bus Miles	6,000,000
Annual Bus Hours	461,538

PERSONNEL DATA

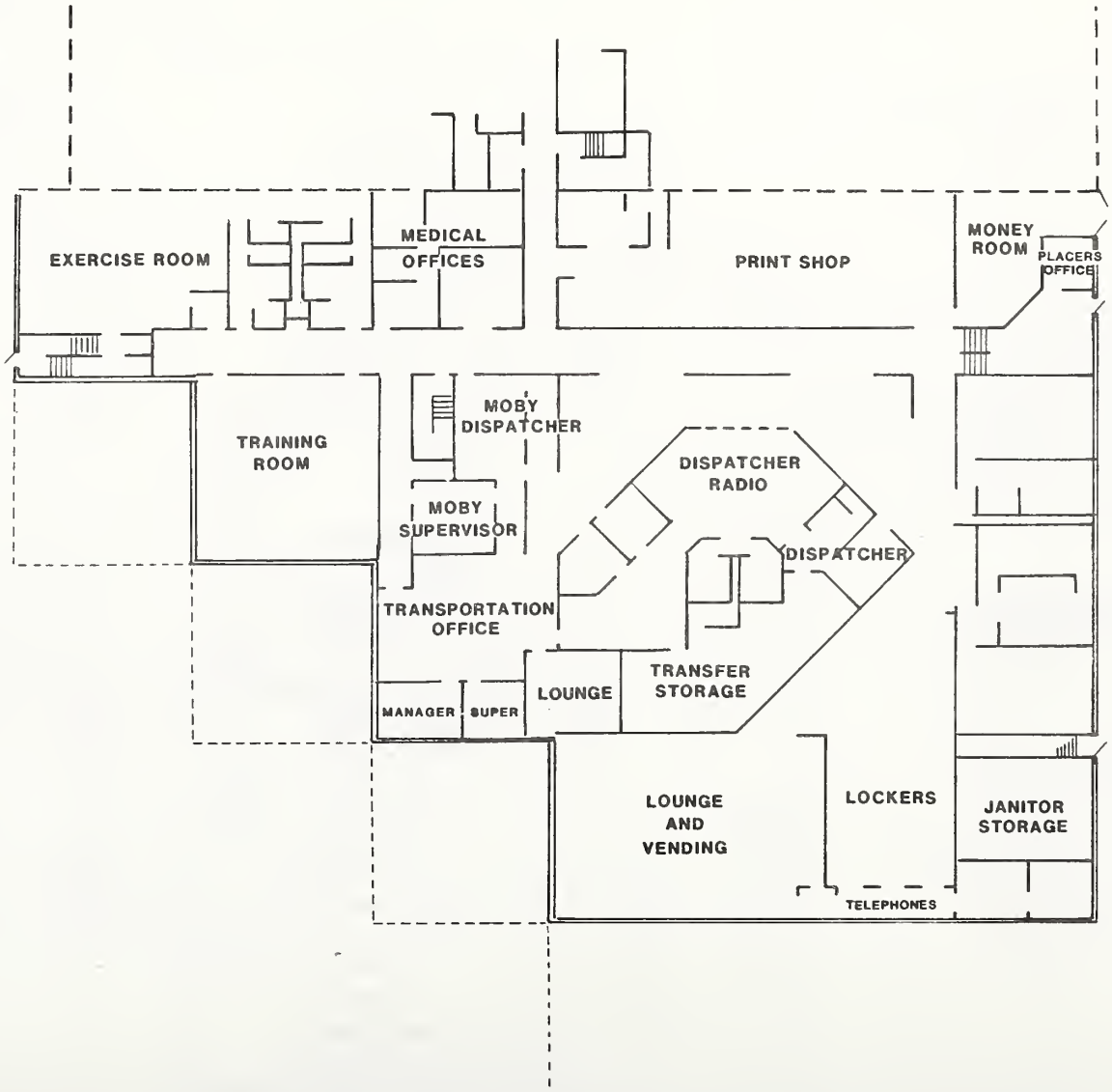
Total	401
Administrative	85
Transportation	242
Drivers	230
Other	12
Maintenance	74
Mechanics	65
Service	0
Other	9



OMAHA / THE TRANSIT AUTHORITY
CITY OF OMAHA

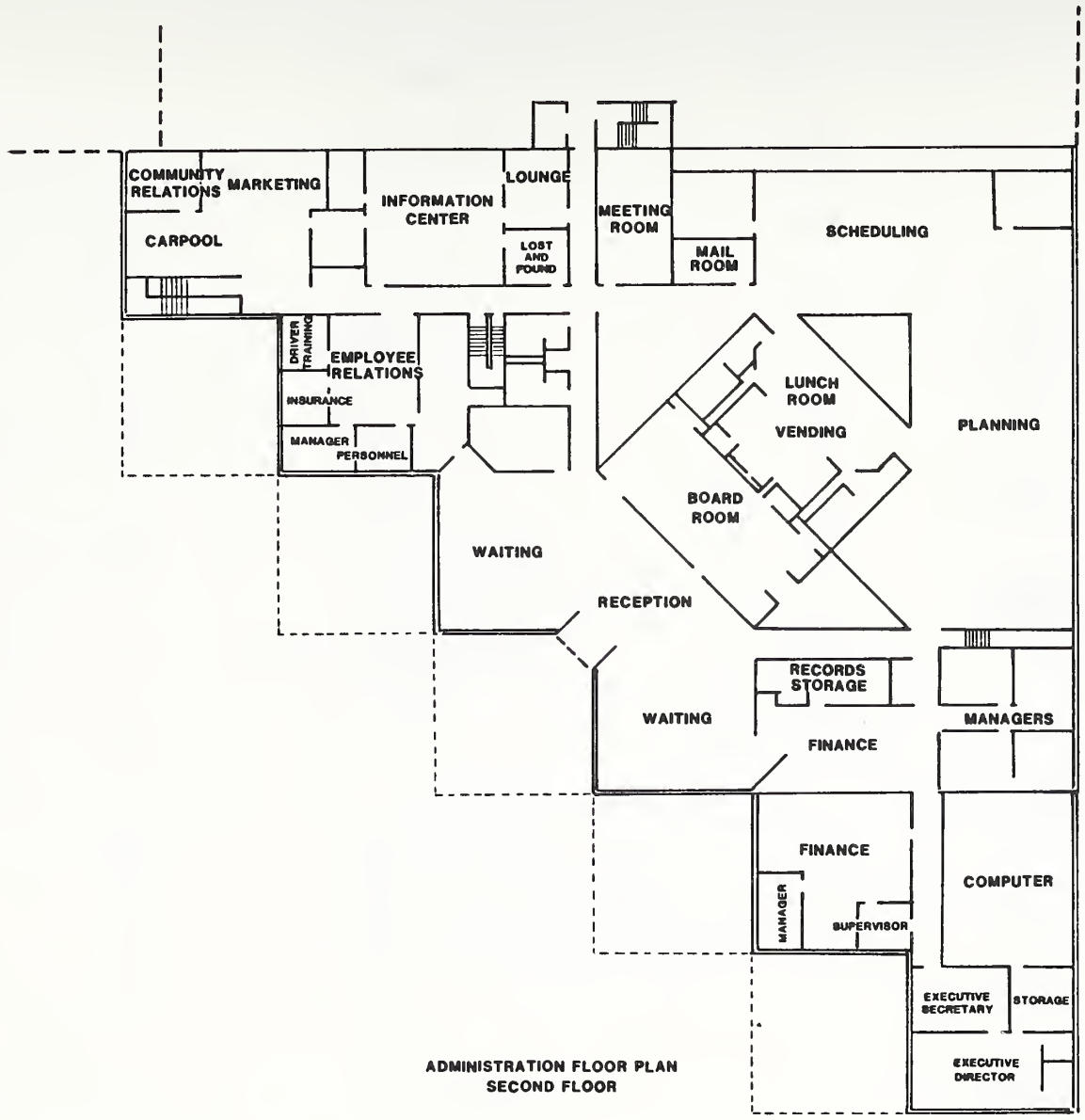
Architect: Michael Baker, Jr., Inc., Consulting Engineers
Bahr, Vermeer & Haecker Architects, Ltd.

Year Opened: 1983



TRANSPORTATION FLOOR PLAN
FIRST FLOOR

OMAHA / THE TRANSIT AUTHORITY
CITY OF OMAHA



ADMINISTRATION FLOOR PLAN
SECOND FLOOR

OMAHA / THE TRANSIT AUTHORITY
CITY OF OMAHA

PENSACOLA / ESCAMBIA TRANSIT SYSTEM
PENSACOLA, FLORIDA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	196
Offices	955
Conference Room	224
Other	470
** TOTAL **	1845

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	950
Training Room	322
Lunch Room	0
Radio,Dispatch	350
Fare Box Room	0
Storage	0
** TOTAL **	1892

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	11
Indoor Parking Spaces	0
Number of Axle Lifts	5
Number of Wheel Lifts	5
Number of Pits	1

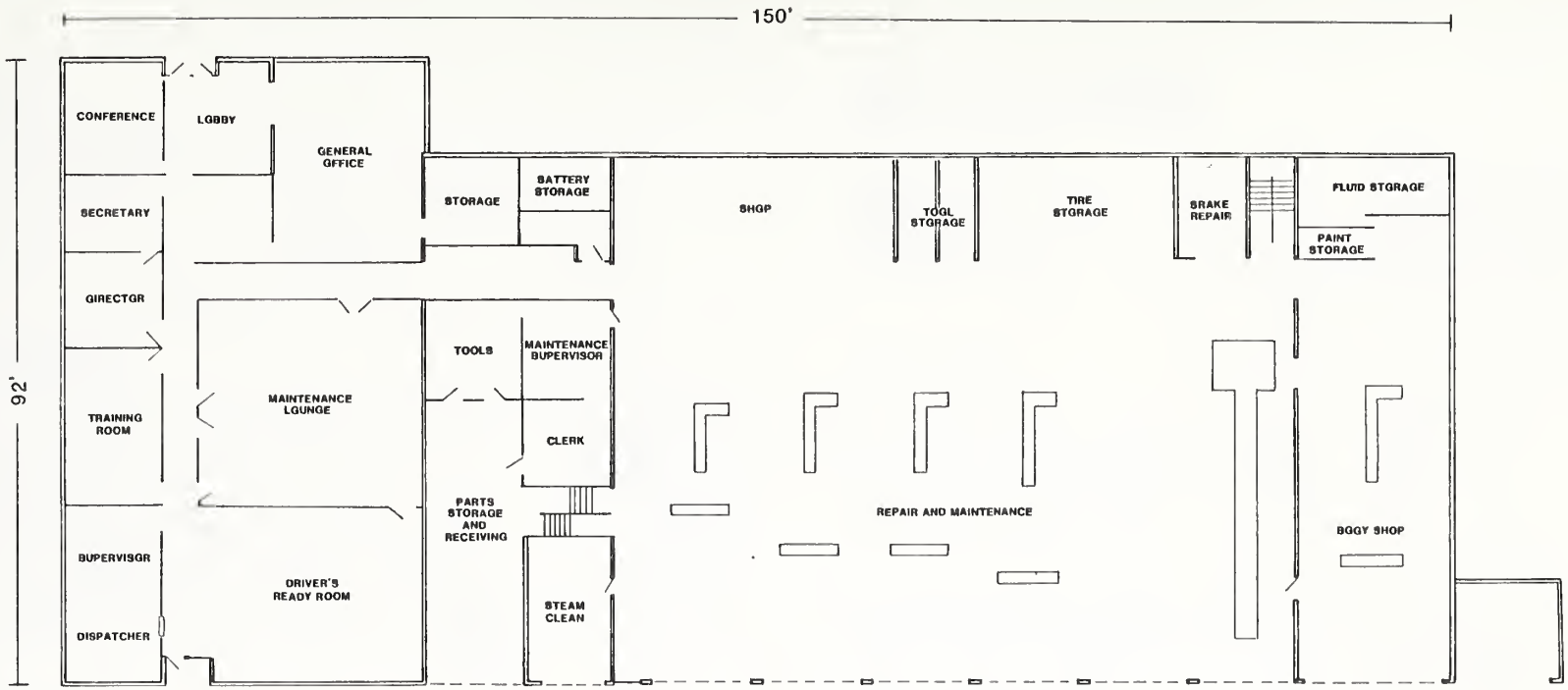
	(sq. ft.)
Offices	144
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	6220
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	560
Storage	651
Lunch Room	236
Paint Booth	0
Steam Bay	220
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	144
Brake Repair	140
** TOTAL **	15782

OPERATIONAL DATA

Capacity	50
Fleet	29
Peak Buses	20
Base Buses	20
Annual Bus Miles	964,000
Annual Bus Hours	74,048

PERSONNEL DATA

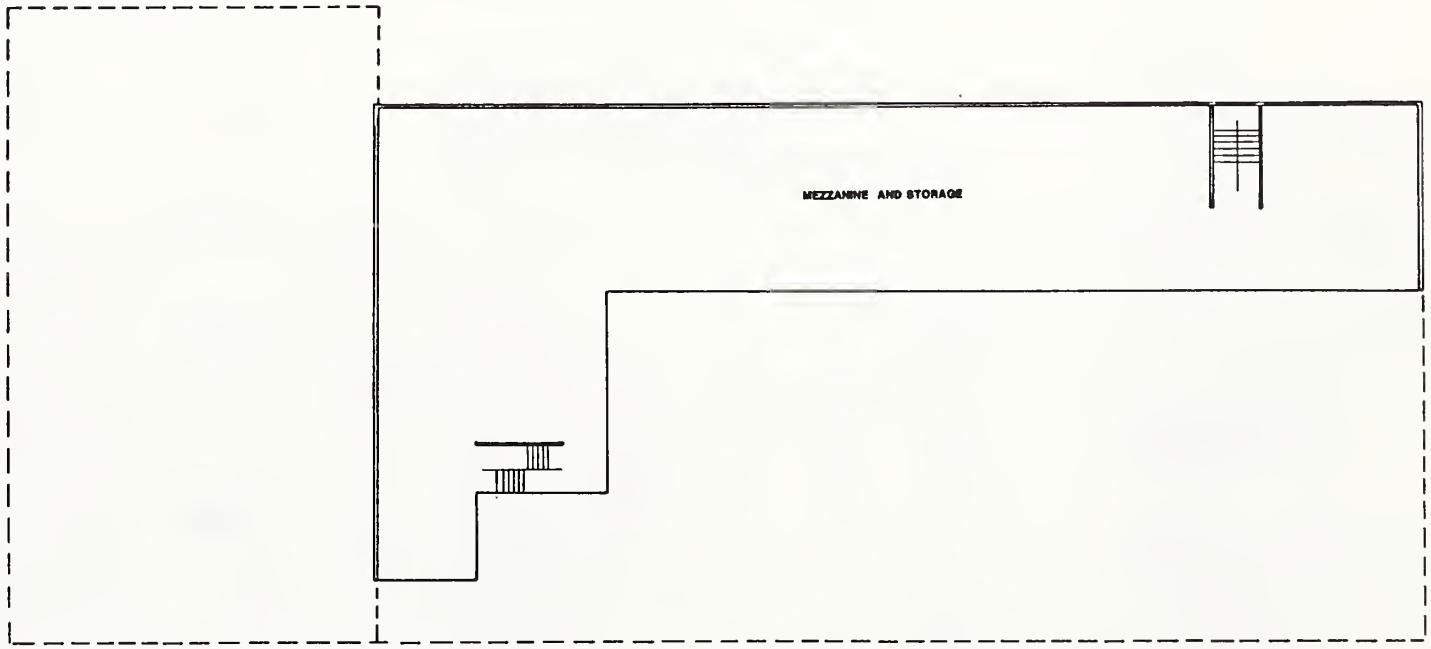
Total	68
Administrative	6
Transportation	38
Drivers	35
Other	3
Maintenance	24
Mechanics	18
Service	2
Other	4



FIRST FLOOR PLAN

PENSACOLA / ESCAMBIA TRANSIT SYSTEM
MAINTENANCE FACILITY

Architect: Barritt, Daffin & Carlan, Inc.
Year Opened: 1981



MEZZANINE FLOOR PLAN

PENSACOLA / ESCAMBIA TRANSIT SYSTEM
MAINTENANCE FACILITY

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	Precast Concrete Panels
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	25'-0"
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	16'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	10'-0"
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Fluorescent
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	Incandescent

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Electric Resistance
Heat Source Fuel	Electricity
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	No

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	No
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

RALEIGH / CITY OF RALEIGH
RALEIGH, NORTH CAROLINA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	182
Offices	780
Conference Room	408
Other	170
** TOTAL **	1540

TRANSPORTATION SPACE

	(sq. ft.)
Offices	160
Locker Room	593
Train Room	750
Training Room	0
Lunch Room	0
Radio,Dispatch	196
Fare Box Room	0
Storage	0
** TOTAL **	2304

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	5
Indoor Parking Spaces	0
Number of Axle Lifts	5
Number of Wheel Lifts	0
Number of Pits	0

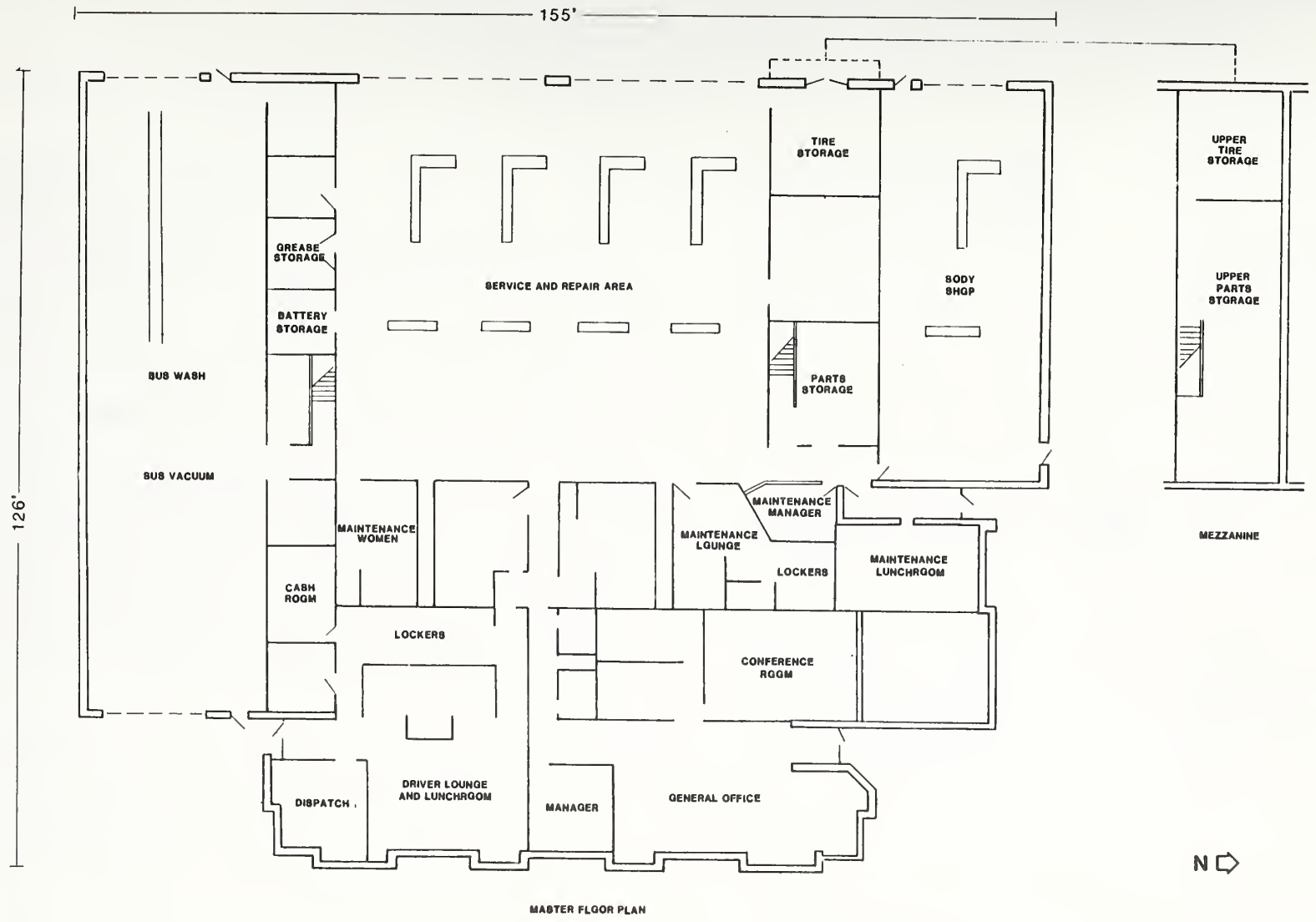
	(sq. ft.)
Offices	96
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	4723
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	1087
Storage	178
Lunch Room	260
Paint Booth	0
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	100
Brake Repair	0
** TOTAL **	12641

OPERATIONAL DATA

Capacity	80
Fleet	58
Peak Buses	42
Base Buses	19
Annual Bus Miles	1,476,851
Annual Bus Hours	117,803

PERSONNEL DATA

Total	98
Administrative	6
Transportation	76
Drivers	73
Other	3
Maintenance	16
Mechanics	8
Service	5
Other	3



MASTER FLOOR PLAN

RALEIGH / CITY OF RALEIGH
TRANSIT GARAGE

Architect: Michael Baker III, Consulting Engineers
Owen F. Smith, Architect

Year Opened: 1980

BUILDING SHELL

Structural Framing	Masonry and Steel
Exterior Walls	Masonry with Brick Facing
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	30'-0"
Ceiling Height Service Area	30'-0"
Bus Garage Door Opening Height	25'-0"
Bus Garage Door Opening Width	14'-0",16'-0,26'-0"
Ceiling Height, Main Parts Level	NA
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Fluorescent
Low Bay Area	NA
Bus Storage Area	NA
Exterior Areas	Mercury - Vapor

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Oil/Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	No
Security System	Card Controlled Access
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

SCRANTON / COUNTY OF LACAWANNA TRANSIT SYSTEM
SCRANTON, PENNSYLVANIA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	180
Offices	750
Conference Room	0
Other	40
** TOTAL **	970

TRANSPORTATION SPACE

	(sq. ft.)
Offices	674
Locker Room	600
Train Room	322
Training Room	900
Lunch Room	0
Radio,Dispatch	132
Fare Box Room	0
Storage	290
** TOTAL **	3940

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	10
Indoor Parking Spaces	50
Number of Axle Lifts	1
Number of Wheel Lifts	0
Number of Pits	2

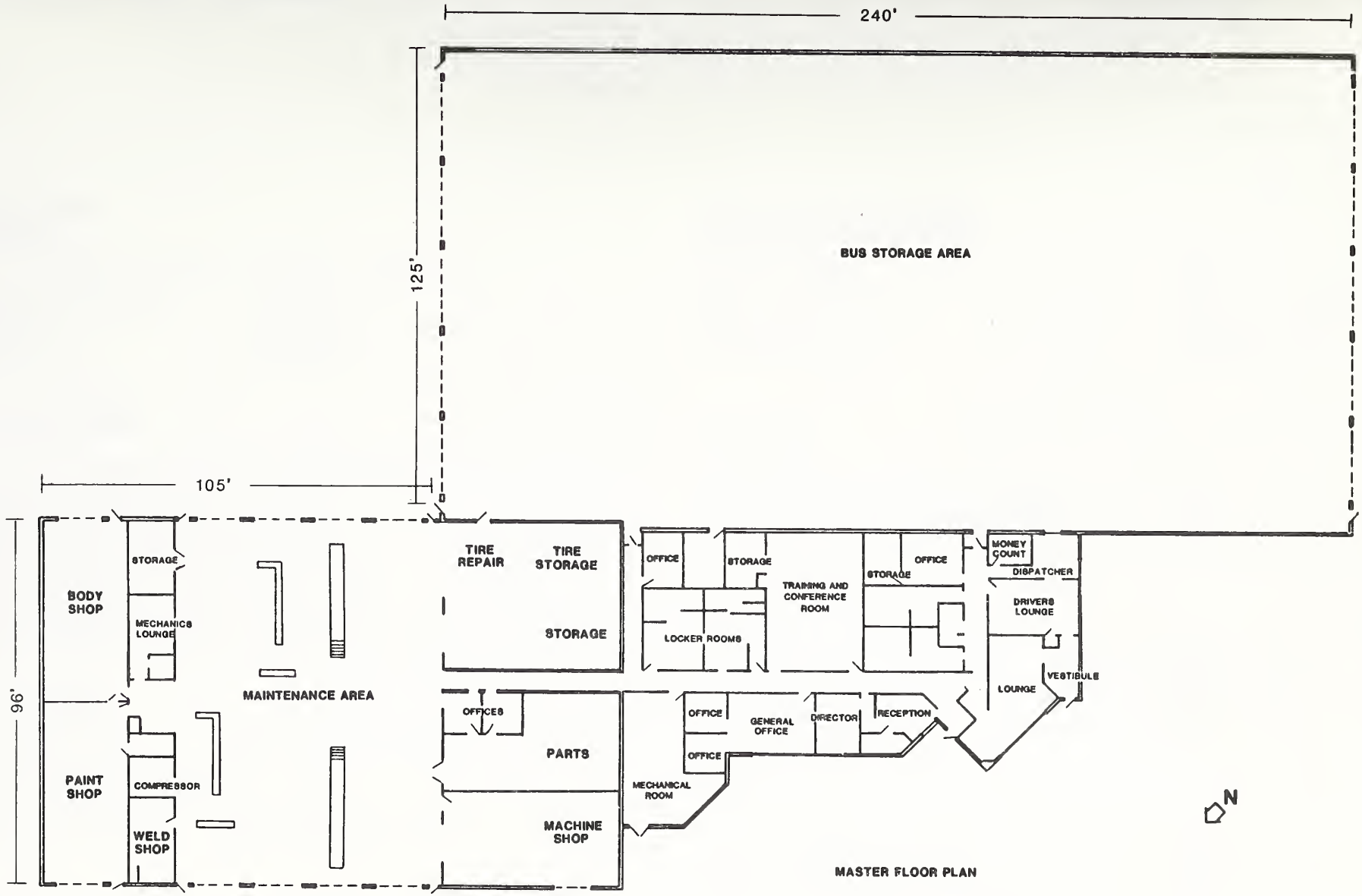
	(sq. ft.)
Offices	200
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	7522
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	858
Storage	1081
Lunch Room	0
Paint Booth	1012
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	242
** TOTAL **	13783

OPERATIONAL DATA

Capacity	50
Fleet	36
Peak Buses	26
Base Buses	21
Annual Bus Miles	1,271,343
Annual Bus Hours	99,187

PERSONNEL DATA

Total	78
Administrative	5
Transportation	58
Drivers	54
Other	4
Maintenance	15
Mechanics	11
Service	3
Other	1



SCRANTON / COUNTY OF LACKAWANNA TRANSIT SYSTEM
OPERATIONS / MAINTENANCE TERMINAL

Architect: Loewe Associates, Architects, Engineers and Planners
Year Opened: 1979

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	20'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	20'-0"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	6'-0"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	NA
Bus Storage Area	Fluorescent
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	No
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	Alarms
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

WILMINGTON / OPERATIONS CENTER DART
DELAWARE TRANSIT AUTHORITY
WILMINGTON, DELAWARE

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	312
Offices	1601
Conference Room	266
Other	1009
** TOTAL **	3188

TRANSPORTATION SPACE

	(sq. ft.)
Offices	636
Locker Room	0
Train Room	962
Training Room	0
Lunch Room	0
Radio,Dispatch	411
Fare Box Room	0
Storage	64
** TOTAL **	2450

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	12
Indoor Parking Spaces	0
Number of Axle Lifts	8
Number of Wheel Lifts	0
Number of Pits	0

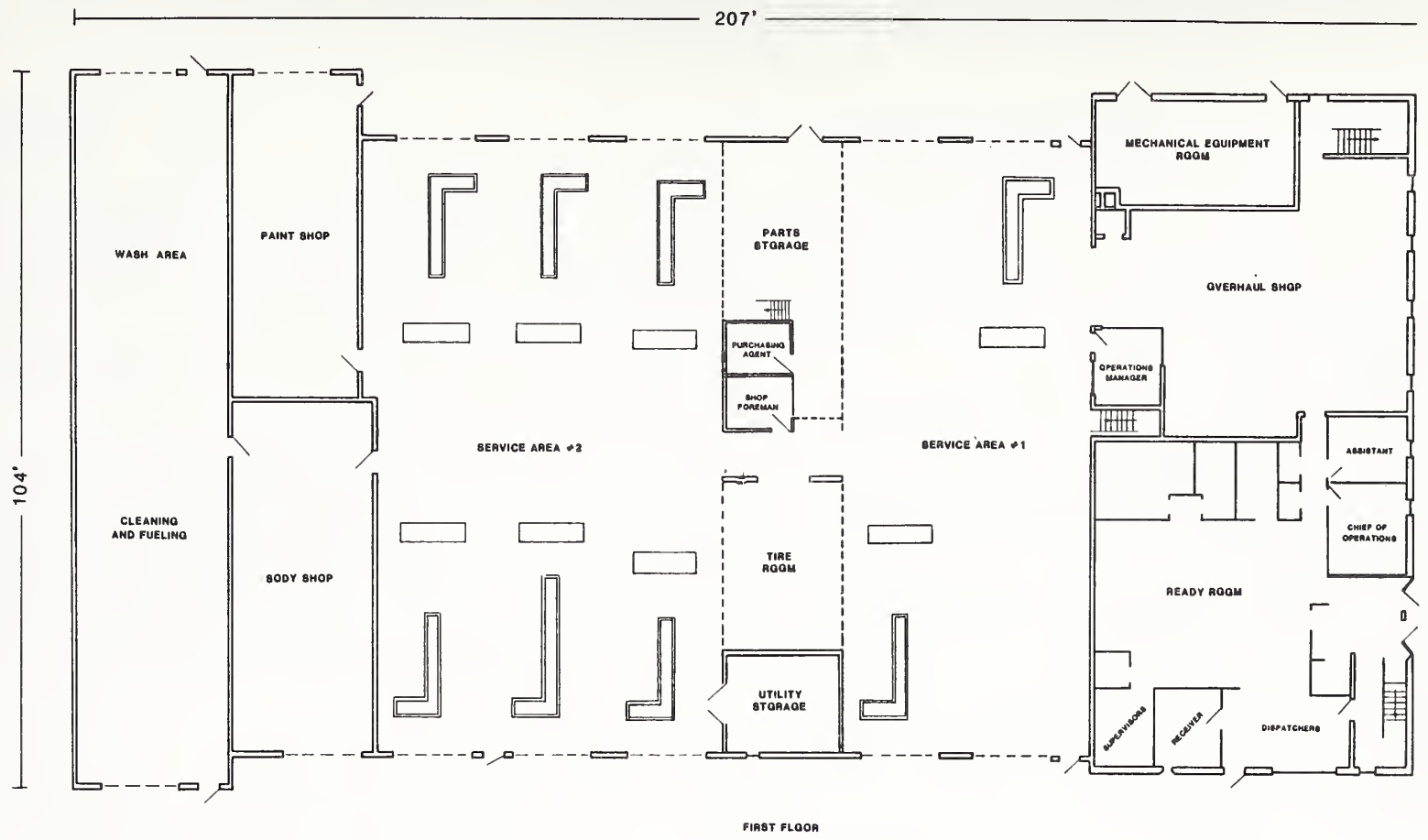
	(sq. ft.)
Offices	220
Locker Room	450
Body Repair	0
Dynamometer Bay	0
General Repair	9024
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	630
Storage	470
Lunch Room	0
Paint Booth	950
Steam Bay	0
Overhaul	2000
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	0
** TOTAL **	18765

OPERATIONAL DATA

Capacity	200
Fleet	100
Peak Buses	87
Base Buses	40
Annual Bus Miles	2,212,344
Annual Bus Hours	17,105

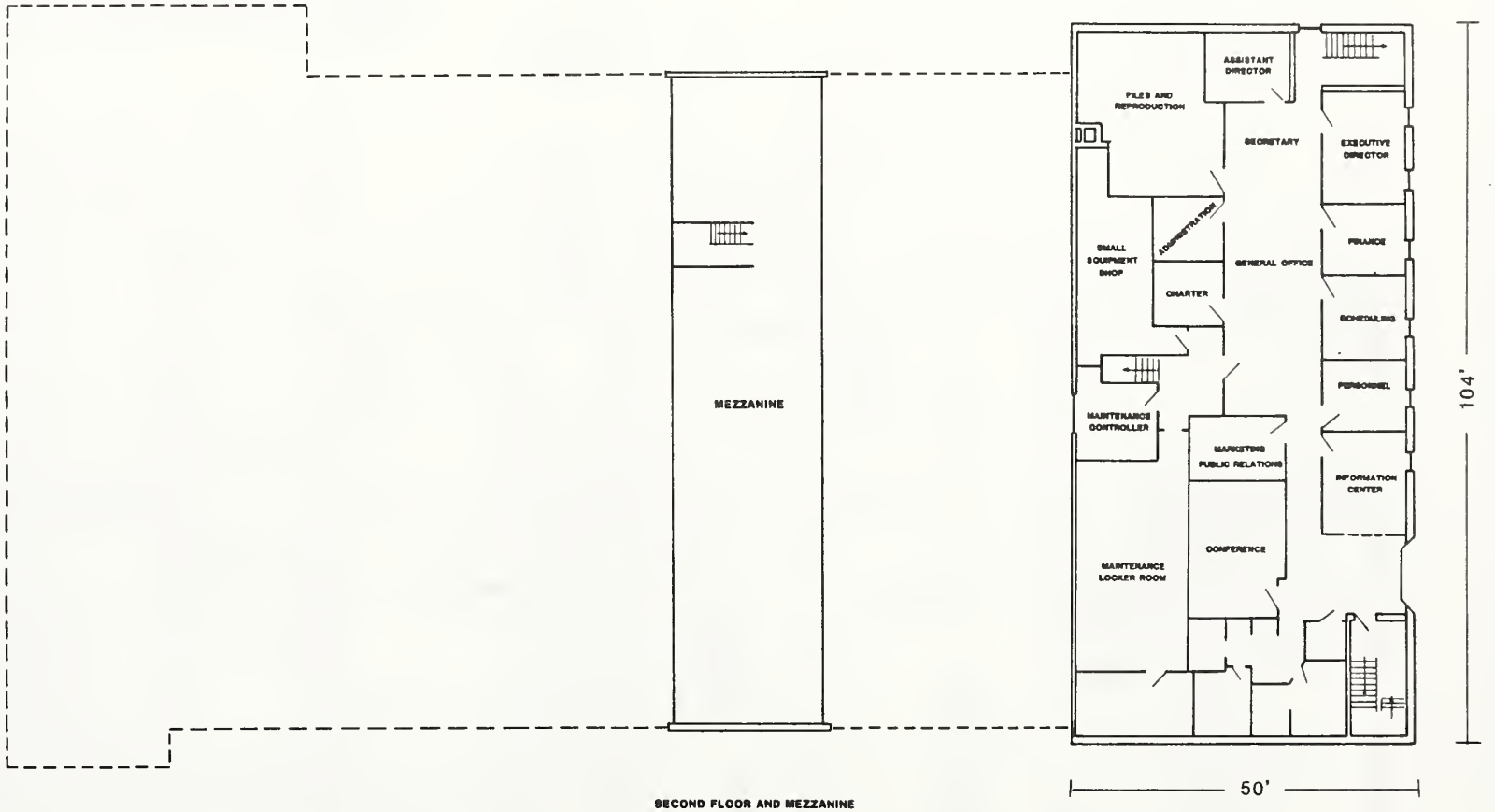
PERSONNEL DATA

Total	174
Administrative	9
Transportation	123
Drivers	114
Other	9
Maintenance	42
Mechanics	21
Service	9
Other	12



WILMINGTON / DART OPERATIONS CENTER
DELAWARE TRANSIT AUTHORITY

Architect: Waymon & Fidance
Year Opened: 1976



SECOND FLOOR AND MEZZANINE

WILMINGTON / DART OPERATIONS CENTER
DELAWARE TRANSIT AUTHORITY

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Masonry w/Brick Veneer, Insulated
Roof	Metal Deck Metal Panels
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	17'-9"
Ceiling Height Service Area	16'-6"
Bus Garage Door Opening Height	12'-3"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	9'-6"
Ceiling Height, Upper Parts Level	6'-6"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Unit Heaters
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	Closed Circuit TV
Computer Energy Management	Yes
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

ALBANY / SCHENECTADY GARAGE
CAPITAL DISTRICT TRANSPORTATION AUTHORITY
SCHENECTADY, NEW YORK

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	324
Offices	642
Conference Room	0
Other	45
** TOTAL **	1011

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	200
Fare Box Room	0
Storage	0
** TOTAL **	1246

MAINTENANCE SPACE

Number of Service Lanes	1
Number of Maintenance Bays	3
Indoor Parking Spaces	40
Number of Axle Lifts	2
Number of Wheel Lifts	0
Number of Pits	1

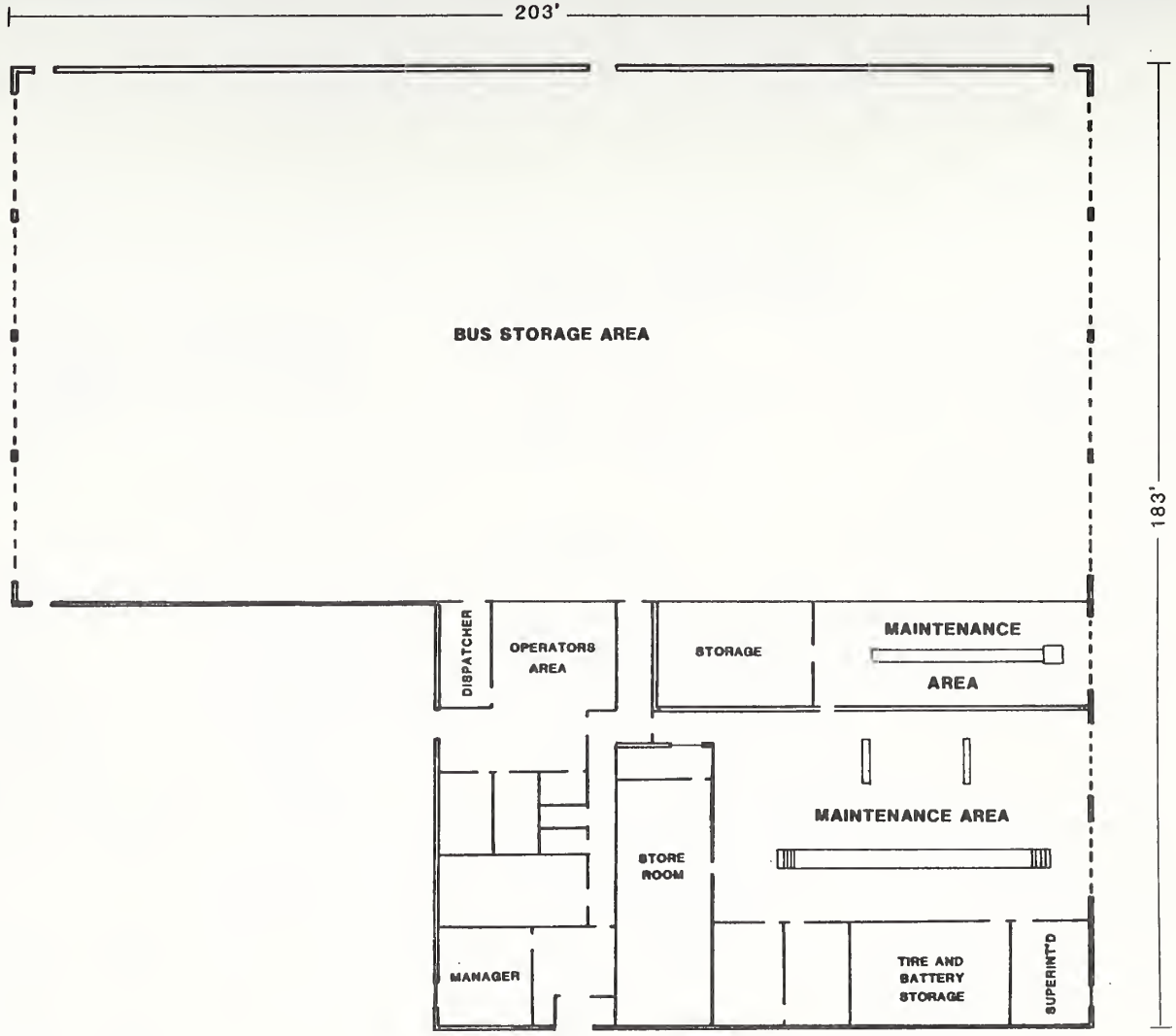
	(sq. ft.)
Offices	300
Locker Room	240
Body Repair	0
Dynamometer Bay	0
General Repair	2800
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	1089
Storage	600
Lunch Room	0
Paint Booth	0
Steam Bay	900
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	0
** TOTAL **	9244

OPERATIONAL DATA

Capacity	40
Fleet	44
Peak Buses	39
Base Buses	18
Annual Bus Miles	1,490,000
Annual Bus Hours	

PERSONNEL DATA

Total	20
Administrative	3
Transportation	
Drivers	
Other	
Maintenance	17
Mechanics	6
Service	7
Other	4



MASTER FLOOR PLAN

ALBANY / SCHENECTADY BUS GARAGE
CAPITAL DISTRICT TRANSPORTATION AUTHORITY
Architect: Clough Associates, Consulting Engineers
Year Opened: 1973

BUILDING SHELL

Structural Framing	PreEngineered Metal Building
Exterior Walls	Metal Siding, Ashlar Masonry
Roof	Metal Panels
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	15'-7"
Ceiling Height Service Area	15'-7"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	15'-7"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	4'-8"

LIGHTING

High Bay Area	Mercury - Vapor
Low Bay Area	NA
Bus Storage Area	Mercury - Vapor
Exterior Areas	Mercury - Vapor

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

ALBANY / TROY GARAGE
CAPITAL DISTRICT TRANSPORTATION AUTHORITY
TROY, NEW YORK

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	221
Offices	210
Conference Room	385
Other	1032
** TOTAL **	1848

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	504
Train Room	732
Training Room	0
Lunch Room	0
Radio,Dispatch	565
Fare Box Room	224
Storage	0
** TOTAL **	2214

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	4
Indoor Parking Spaces	70
Number of Axle Lifts	4
Number of Wheel Lifts	0
Number of Pits	0

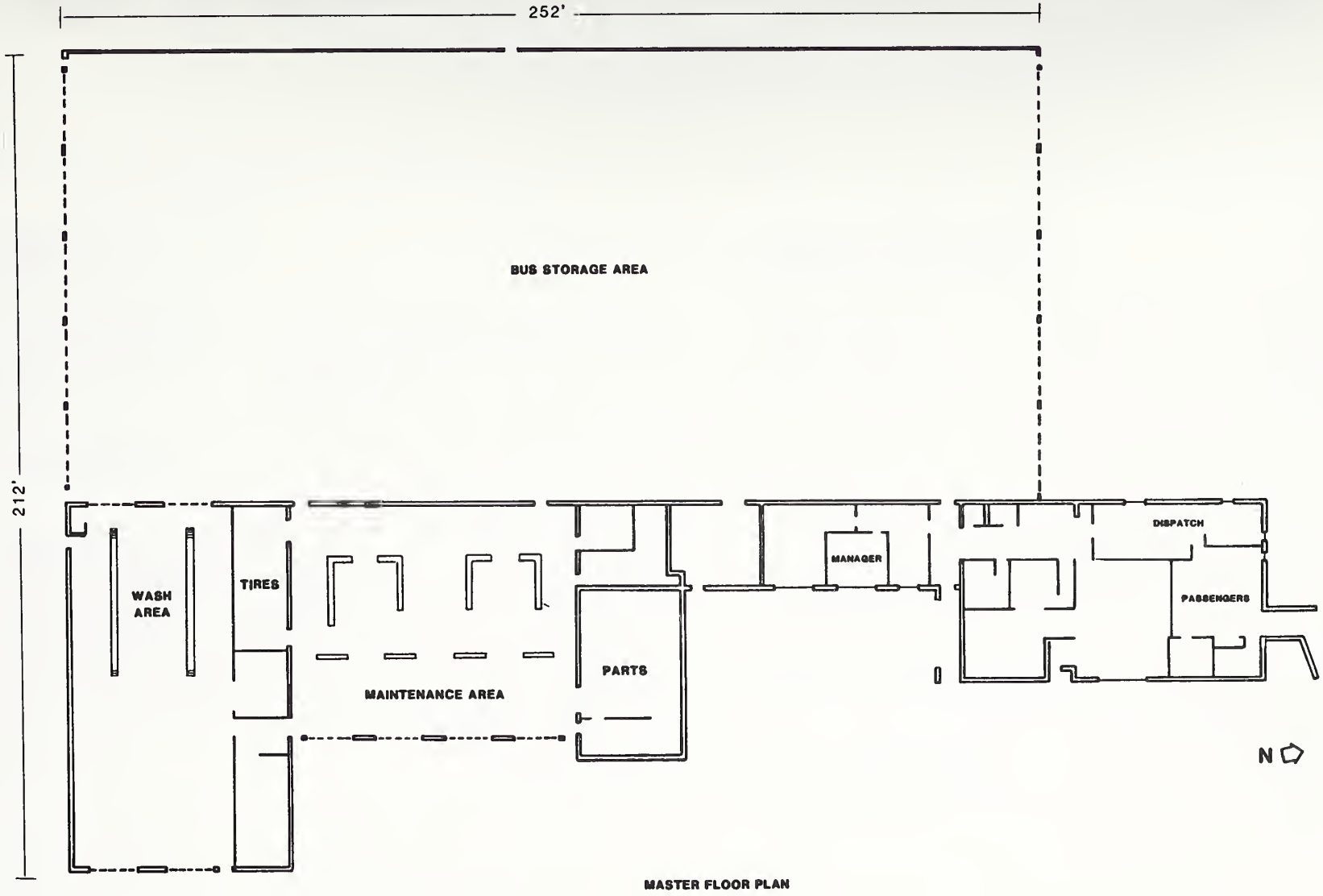
	(sq. ft.)
Offices	158
Locker Room	309
Body Repair	0
Dynamometer Bay	0
General Repair	9428
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	638
Storage	406
Lunch Room	0
Paint Booth	0
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	0
** TOTAL **	16188

OPERATIONAL DATA

Capacity	70
Fleet	67
Peak Buses	56
Base Buses	40
Annual Bus Miles	1,880,000
Annual Bus Hours	

PERSONNEL DATA

Total	112
Administrative	3
Transportation	89
Drivers	83
Other	6
Maintenance	20
Mechanics	8
Service	6
Other	6



MASTER FLOOR PLAN

ALBANY / TROY GARAGE
CAPITAL DISTRICT TRANSPORTATION AUTHORITY
Architect: Hartheimer Bender & Estey, Architects & Engineers
Year Opened: 1981

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Precast Concrete Panels, Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	24'-8"
Ceiling Height Service Area	20'-8"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	20'-0"
Ceiling Height, Main Parts Level	16'-6"
Ceiling Height, Upper Parts Level	6'-8"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Multi-Vapor
Low Bay Area	NA
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Unit Heaters
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	Yes
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

ALBANY / WATERVLIET CENTRAL OPERATING AND HEAVY MAINTENANCE FACILITY
CAPITAL DISTRICT TRANSPORTATION AUTHORITY
ALBANY, NEW YORK

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	N/A
Offices	N/A
Conference Room	N/A
Other	N/A
** TOTAL **	N/A

TRANSPORTATION SPACE

	(sq. ft.)
Offices	N/A
Locker Room	N/A
Train Room	N/A
Training Room	N/A
Lunch Room	N/A
Radio,Dispatch	N/A
Fare Box Room	N/A
Storage	N/A
** TOTAL **	N/A

MAINTENANCE SPACE

Number of Service Lanes	0
Number of Maintenance Bays	17
Indoor Parking Spaces	N/A
Number of Axle Lifts	16
Number of Wheel Lifts	0
Number of Pits	0

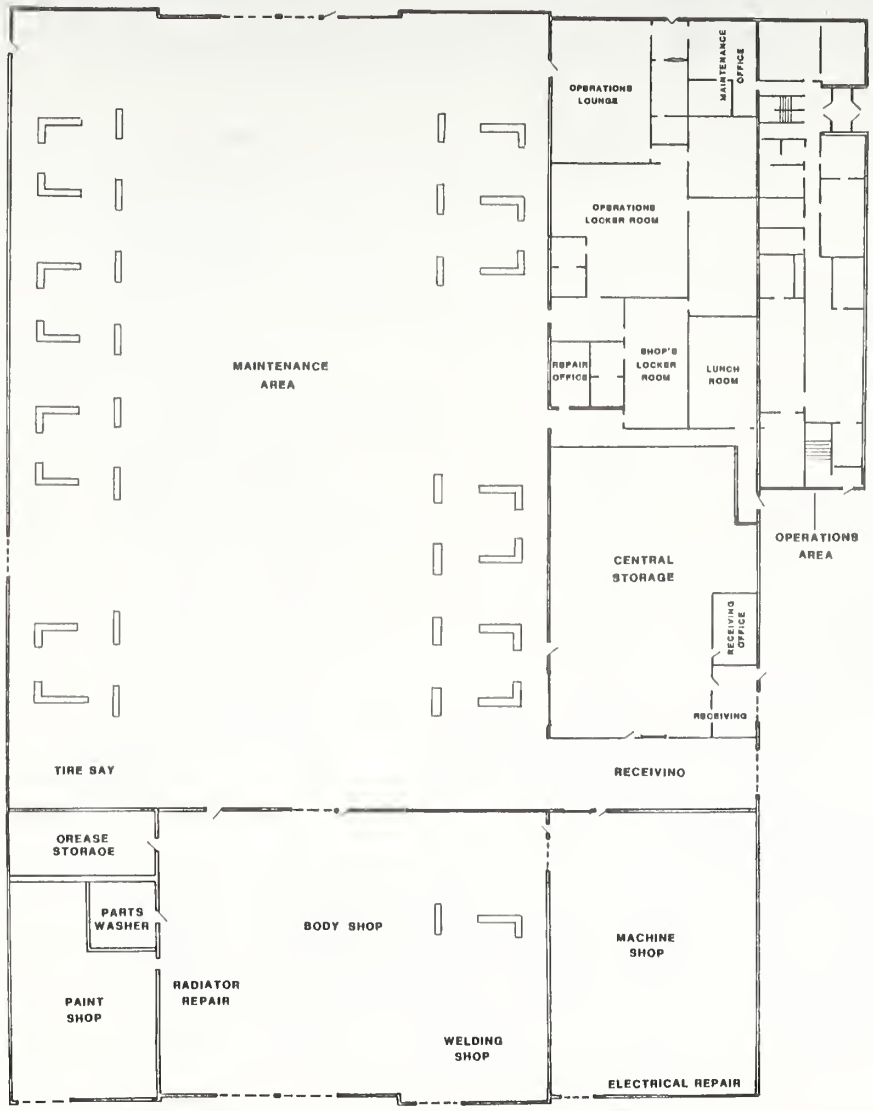
	(sq. ft.)
Offices	721
Locker Room	931
Body Repair	3550
Dynamometer Bay	0
General Repair	33000
Parts Cleaning	400
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	5800
Storage	800
Lunch Room	540
Paint Booth	2000
Steam Bay	0
Overhaul & Machine Shop	4480
Fare Box Repair	0
Tire Bay	800
Battery Room	0
** TOTAL **	53022

OPERATIONAL DATA

Capacity	N/A
Fleet	230
Peak Buses	N/A
Base Buses	N/A
Annual Bus Miles	N/A
Annual Bus Hours	N/A

PERSONNEL DATA

Total	62
Administrative	N/A
Transportation	N/A
Drivers	N/A
Other	N/A
Maintenance	62
Mechanics	41
Service	21
Other	0



ALBANY / WATERVLIET CENTRAL OPERATING AND HEAVY MAINTENANCE FACILITY
CAPITAL DISTRICT TRANSPORTATION AUTHORITY

Architect: Lux Quackenbush
Year Opened: 1968

ATLANTA-BROWNS MILL / TRANSIT HEAVY MAINTENANCE
METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY
ATLANTA, GEORGIA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	0

MAINTENANCE SPACE

Number of Service Lanes	0
Number of Maintenance Bays	63
Indoor Parking Spaces	0
Number of Axle Lifts	23
Number of Wheel Lifts	0
Number of Pits	3

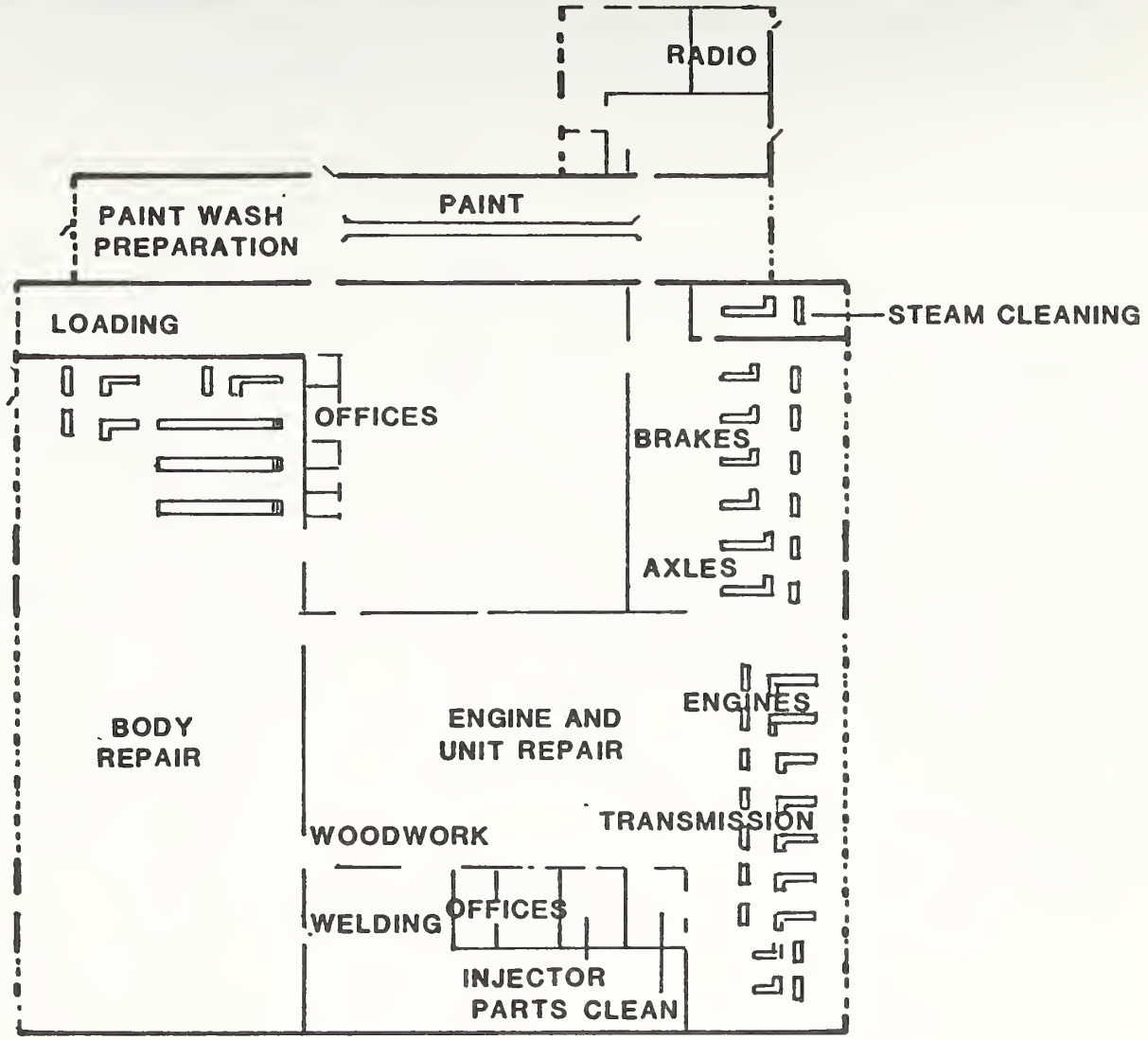
	(sq. ft.)
Offices	2725
Locker Room	7380
Body Repair	43200
Dynamometer Bay	0
General Repair	1428
Parts Cleaning	1073
Injector Room	0
Brake Bay & Repair	13700
Wheel Alignment	0
Parts Room	26685
Storage	3342
Lunch Room	0
Paint Booth	17940
Steam Bay	1850
Overhaul & Machine Shop	24000
Fare Box Repair	0
Tire Bay	0
Battery Room	0
** TOTAL **	143323

OPERATIONAL DATA

Capacity	-
Fleet	740
Peak Buses	-
Base Buses	-
Annual Bus Miles	N/A
Annual Bus Hours	N/A

PERSONNEL DATA

Total	
Administrative	10
Transportation	0
Drivers	0
Other	0
Maintenance	100
Mechanics	89
Service	0
Other	11



MASTER FLOOR PLAN

ATLANTA-BROWNS MILL / HEAVY MAINTENANCE FACILITY
METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY

Architect: Mohorich Associates
Year Opened: 1976

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	PreCast Concrete Panels
Roof	Prestressed Concrete
Floors	Concrete '

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	18'-0"
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	16'-0"
Ceiling Height, Main Parts Level	18'-0"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Infrared Heaters and Hot Air
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	No
Security System	Closed Circuit TV & Guards
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Concrete

BOSTON / SOUTH BAY MAINTENANCE CENTER
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
BOSTON, MASSACHUSETTS

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	2451
Conference Room	0
Other	756
** TOTAL **	3207

TRANSPORTATION SPACE

	(sq. ft.)
Offices	2977
Locker Room	2340
Train Room	330
Training Room	1000
Lunch Room	5124
Radio,Dispatch	160
Fare Box Room	430
Storage	0
** TOTAL **	12829

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	11
Indoor Parking Spaces	180
Number of Axle Lifts	7
Number of Wheel Lifts	5
Number of Pits	0

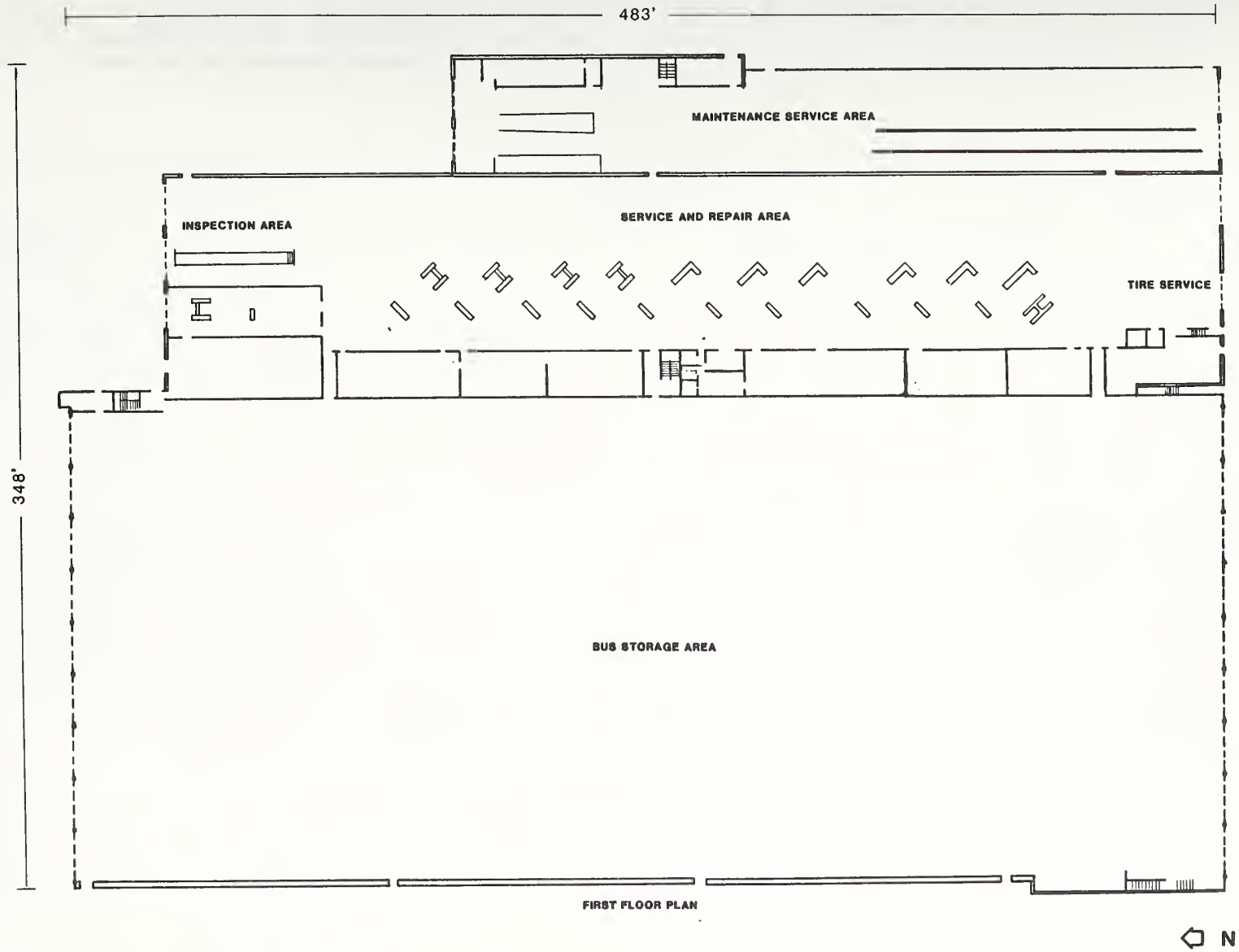
	(sq. ft.)
Offices	310
Locker Room	1032
Body Repair	0
Dynamometer Bay	0
General Repair	28367
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	1224
Storage	6658
Lunch Room	0
Paint Booth	0
Steam Bay	1152
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	720
Brake Repair	0
** TOTAL **	62297

OPERATIONAL DATA

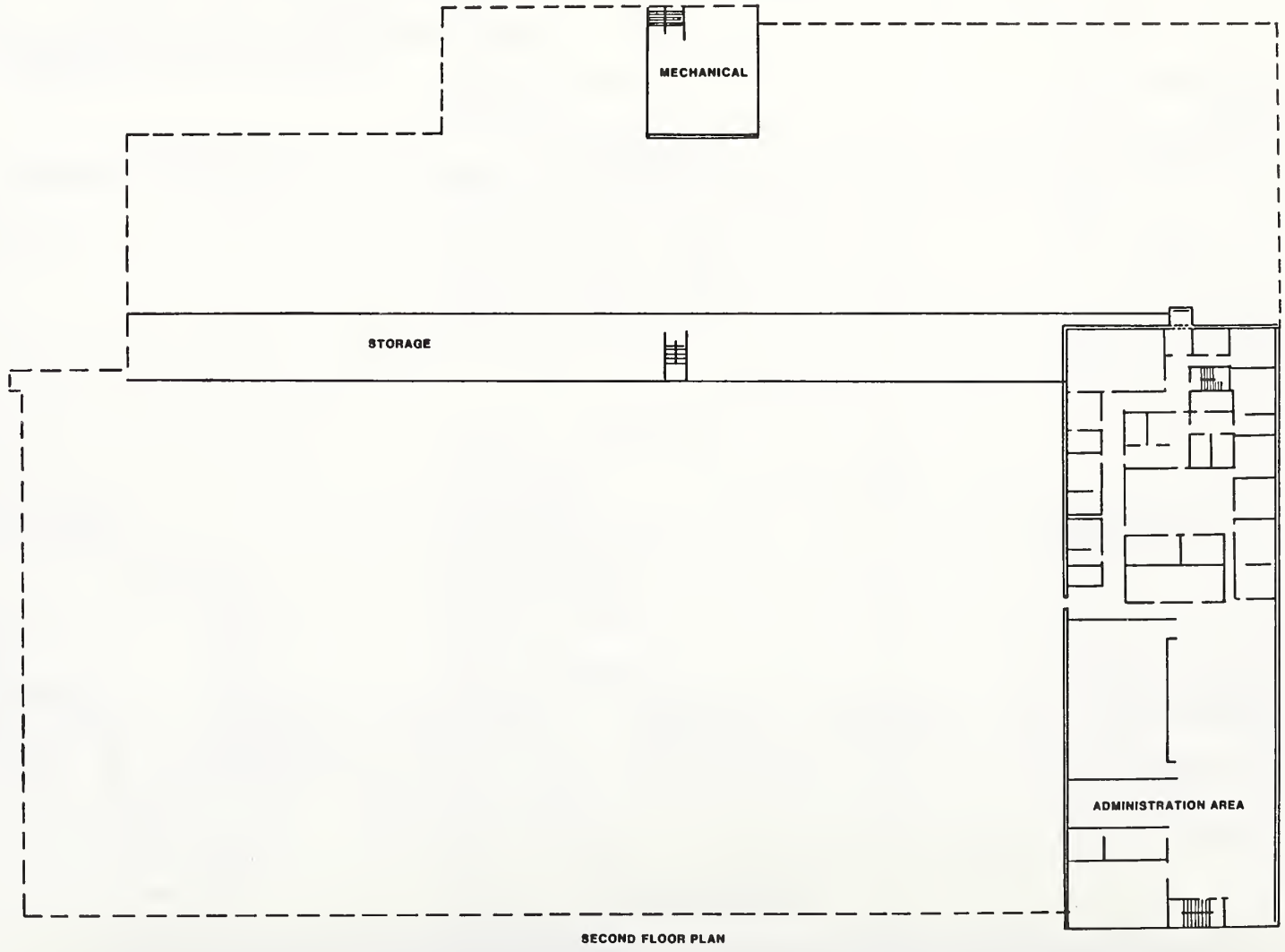
Capacity	180
Fleet	145
Peak Buses	123
Base Buses	90
Annual Bus Miles	3,128,721
Annual Bus Hours	312,900

PERSONNEL DATA

Total	477
Administrative	3
Transportation	400
Drivers	400
Other	4
Maintenance	70
Mechanics	64
Service	0
Other	6



BOSTON / SOUTH BAY MAINTENANCE CENTER
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
Architect: De Leuw, Cather & Company
Year Opened: 1976



SECOND FLOOR PLAN

BOSTON / SOUTH BAY MAINTENANCE CENTER
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	Precast Concrete Panels
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	NA
Ceiling Height Service Area	NA
Bus Garage Door Opening Height	NA
Bus Garage Door Opening Width	NA
Ceiling Height, Main Parts Level	NA
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	NA

LIGHTING

High Bay Area	Mercury Vapor
Low Bay Area	NA
Bus Storage Area	NA
Exterior Areas	Mercury Vapor

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water System
Heat Source Fuel	Gas
Areas Cooled	Office Areas with Window Units

PLUMBING

Heat Source Fuel for Hot Water	Solar and Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

	NA
Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	

OTHER

Emergency Power Source	No
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt

BUFFALO / NEW FRONTIER BUS GARAGE
NIAGARA FRONTIER TRANSPORTATION AUTHORITY
BUFFALO, NEW YORK

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	480
Offices	1104
Conference Room	0
Other	60
** TOTAL **	1644

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	1118
Train Room	480
Training Room	0
Lunch Room	420
Radio,Dispatch	0
Fare Box Room	296
Storage	0
** TOTAL **	6034

MAINTENANCE SPACE

Number of Service Lanes	5
Number of Maintenance Bays	16
Indoor Parking Spaces	175
Number of Axle Lifts	5
Number of Wheel Lifts	1
Number of Pits	8

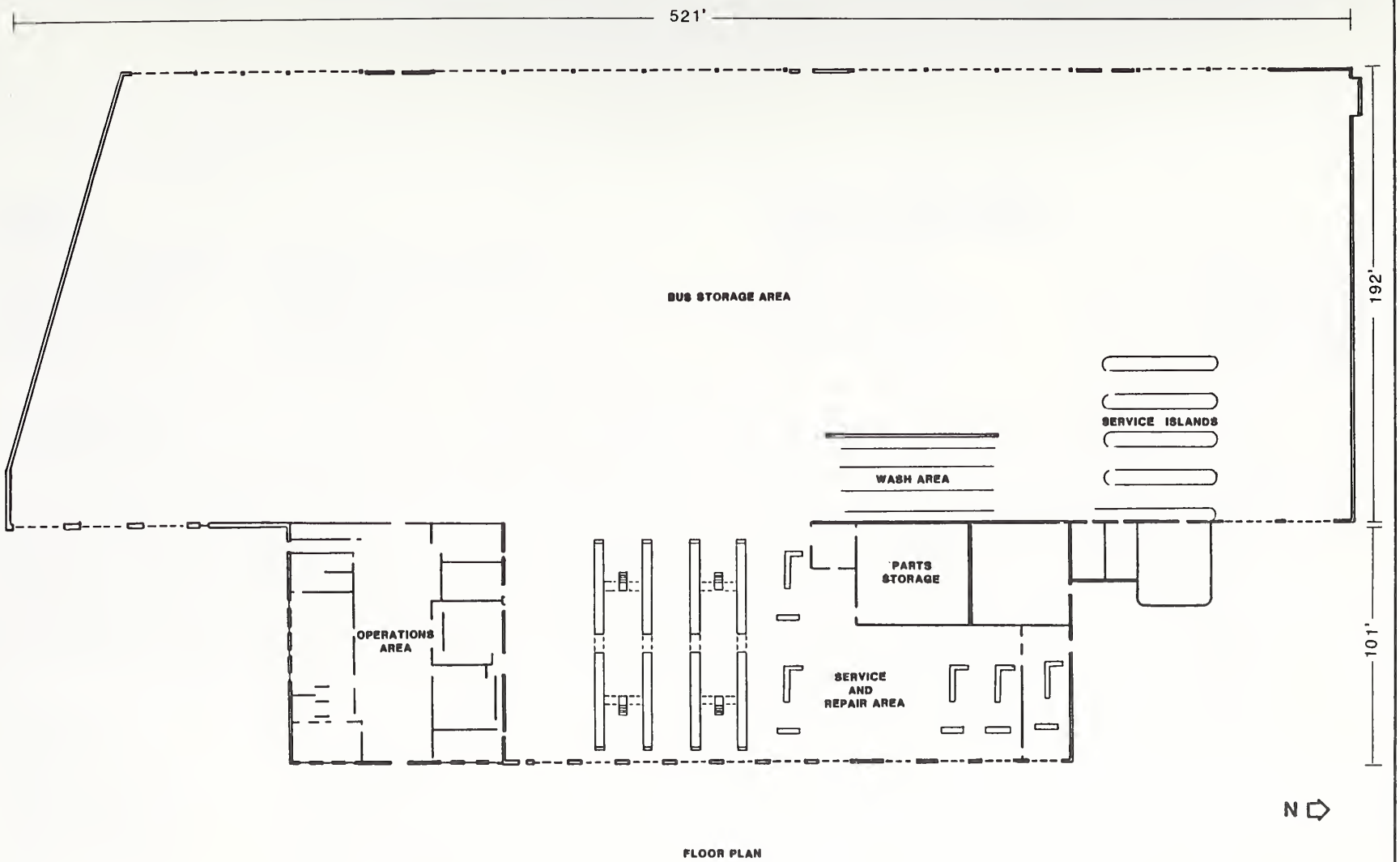
	(sq. ft.)
Offices	400
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	18432
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	2112
Storage	648
Lunch Room	0
Paint Booth	0
Steam Bay	1120
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	80
Brake Repair	0
** TOTAL **	55832

OPERATIONAL DATA

Capacity	175
Fleet	120
Peak Buses	101
Base Buses	
Annual Bus Miles	2,600,000
Annual Bus Hours	

PERSONNEL DATA

Total	198
Administrative	0
Transportation	160
Drivers	160
Other	
Maintenance	38
Mechanics	
Service	
Other	



FLOOR PLAN

BUFFALO / NEW FRONTIER BUS GARAGE
NIAGARA FRONTIER TRANSPORTATION AUTHORITY
Architect: Duchscherer Oberst Associates, P.C.
Year Opened: 1982

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	Masonry
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	24'-0"
Ceiling Height Service Area	18'-0", 20'-0"
Bus Garage Door Opening Height	12'-0"
Bus Garage Door Opening Width	20'-0"
Ceiling Height, Main Parts Level	9'-0"
Ceiling Height, Upper Parts Level	9'-0"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	5'-6"

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	Metal Halide
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water System
Heat Source Fuel	Gas/Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas/Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	Yes
Security System	Door Alarms
Computer Energy Management	Yes
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Concrete Drives, Asphalt Parking

DENVER / BUS MAINTENANCE FACILITY, PLATTE DIVISION
RTD
DENVER, COLORADO

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	1840
Conference Room	0
Other	0
** TOTAL **	1840

TRANSPORTATION SPACE

	(sq. ft.)
Offices	1536
Locker Room	1280
Train Room	2880
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	480
** TOTAL **	6176

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	19
Indoor Parking Spaces	420
Number of Axle Lifts	13
Number of Wheel Lifts	0
Number of Pits	2

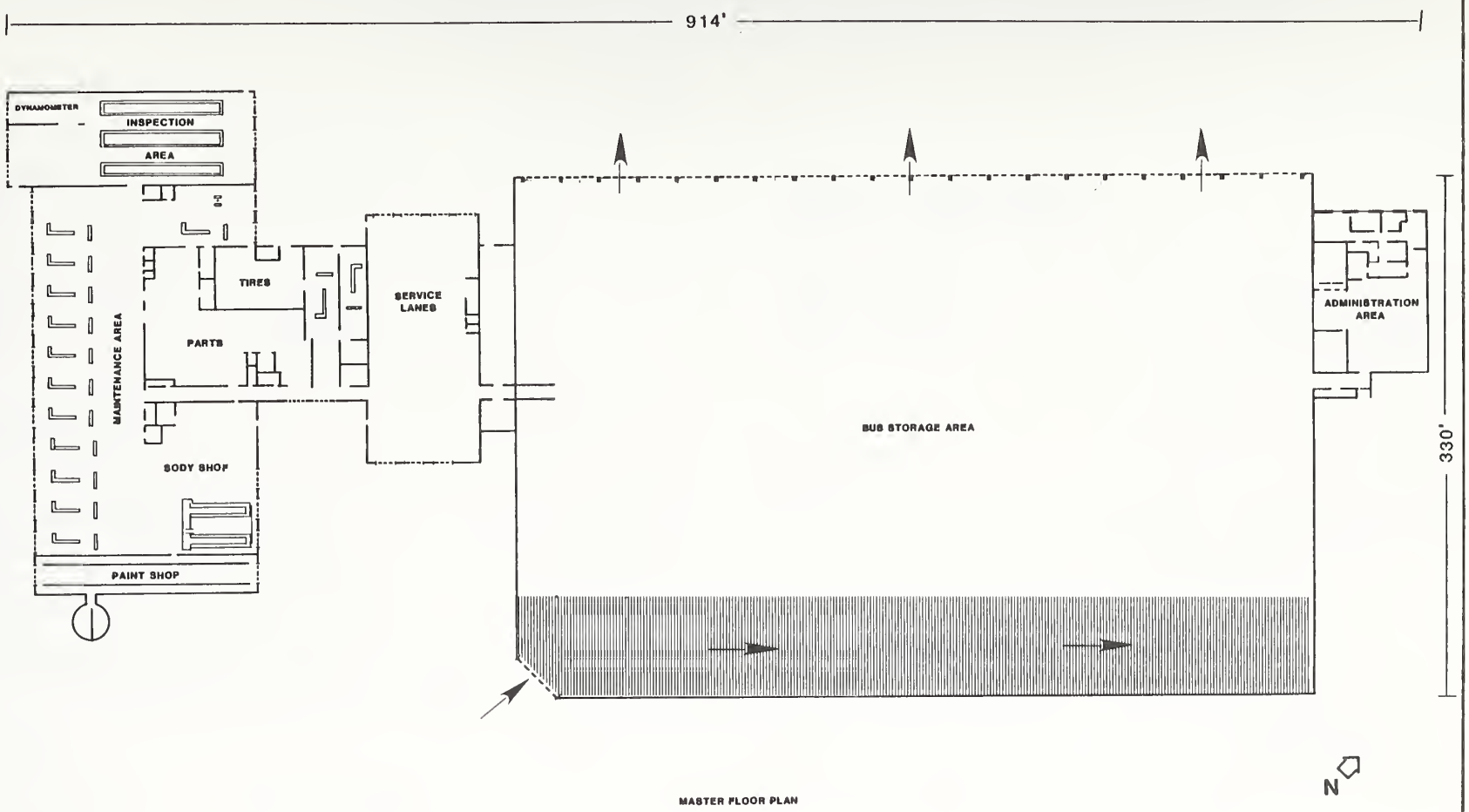
	(sq. ft.)
Offices	1168
Locker Room	0
Body Repair	0
Dynamometer Bay	1120
General Repair	17280
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	9728
Storage	1412
Lunch Room	672
Paint Booth	3456
Steam Bay	1200
Overhaul	0
Fare Box Repair	0
Tire Bay	1440
Machine Shop	0
Battery Room	160
Brake Repair	0
** TOTAL **	64516

OPERATIONAL DATA

Capacity	250
Fleet	233
Peak Buses	191
Base Buses	84
Annual Bus Miles	7,257,000
Annual Bus Hours	518,350

PERSONNEL DATA

Total	456
Administrative	8
Transportation	308
Drivers	299
Other	9
Maintenance	140
Mechanics	105
Service	17
Other	18



MASTER FLOOR PLAN

DENVER / BUS MAINTENANCE FACILITY - PLATTE DIVISION
REGIONAL TRANSPORTATION DISTRICT

Architect: Charles S. Sink & Associates, Architects, P.C.
Year Opened: 1976

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	Masonry
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	24'-0"
Ceiling Height Service Area	24'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	9'-0"
Inspection and Running Repair Pit Depth	4'-6"

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	Fluorescent
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	Yes
Heat Source	Solar and Hot Water Boilers
Heat Source Fuel	Gas/Oil, Solar
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Solar and Gas/Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Water Wash
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	Closed Circuit TV & Door Alarms
Computer Energy Management	No
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Asphalt

DENVER-AURORA / EAST METRO BUS FACILITY
RTD
AURORA, COLORADO

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	1238
Conference Room	256
Other	1471
** TOTAL **	2965

TRANSPORTATION SPACE

	(sq. ft.)
Offices	217
Locker Room	0
Train Room	2357
Training Room	672
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	3471

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	17
Indoor Parking Spaces	250
Number of Axle Lifts	14
Number of Wheel Lifts	1
Number of Pits	1

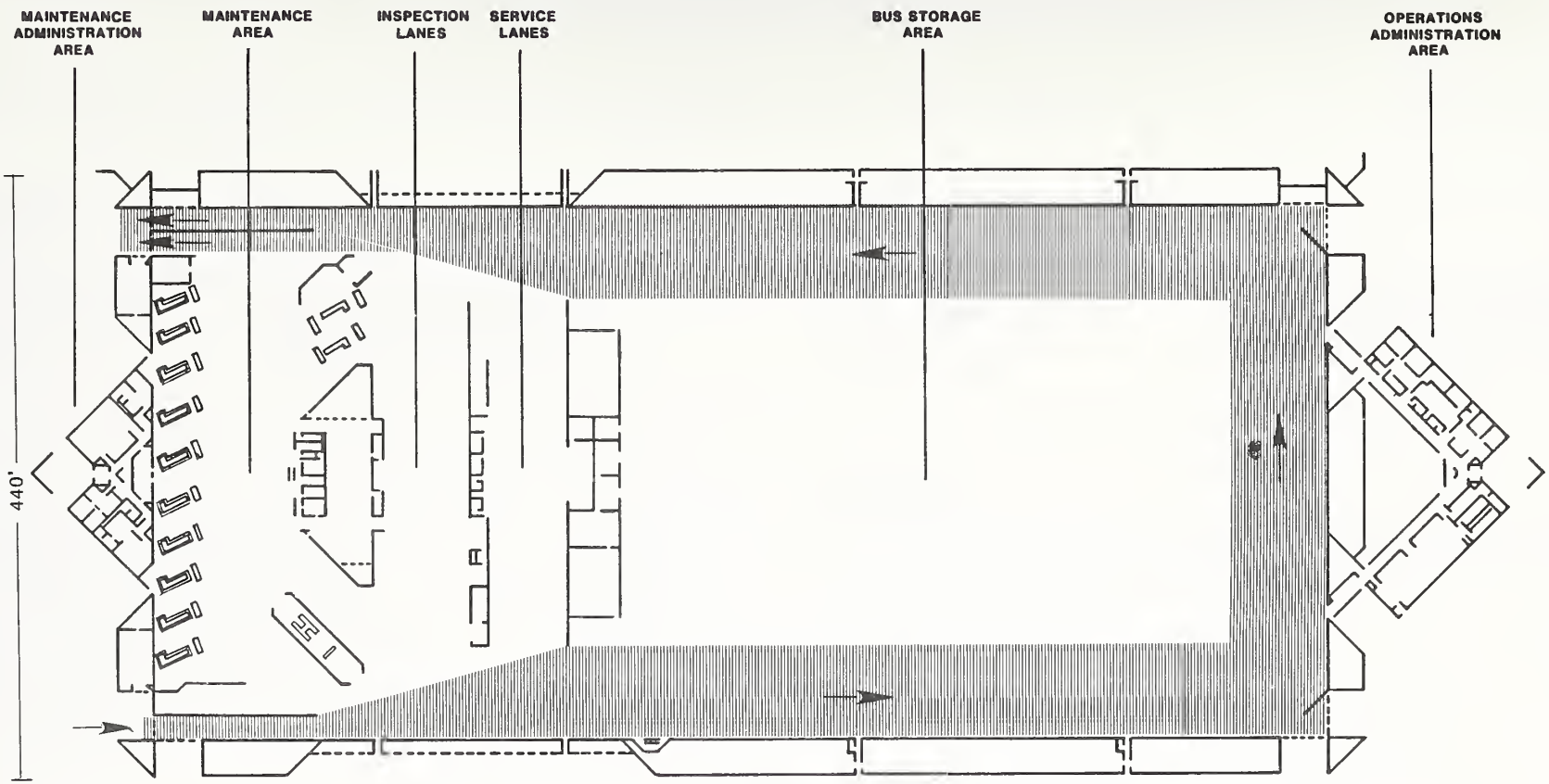
	(sq. ft.)
Offices	685
Locker Room	763
Body Repair	0
Dynamometer Bay	0
General Repair	65620
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	0
Storage	4686
Lunch Room	0
Paint Booth	0
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	0
** TOTAL **	125576

OPERATIONAL DATA

Capacity	250
Fleet	208
Peak Buses	175
Base Buses	83
Annual Bus Miles	6,755,970
Annual Bus Hours	459,510

PERSONNEL DATA

Total	384
Administrative	8
Transportation	291
Drivers	282
Other	9
Maintenance	85
Mechanics	57
Service	0
Other	28



MASTER FLOOR PLAN

DENVER-AURORA / EAST METRO BUS FACILITY
REGIONAL TRANSPORTATION DISTRICT

Architect: Rogers-Nagel-Langhart
Year Opened: 1980

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	PreCast Concrete Panels
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	24'-0"
Ceiling Height Service Area	24'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0", 14'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	10'-0"
Door Height, Forklift Access	9'-0"
Inspection and Running Repair Pit Depth	4'-6"

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	Fluorescent
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	Yes
Heat Source	Solar and Hot Water Boilers
Heat Source Fuel	Gas/Oil, Solar Recovered Heat
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Solar and Gas/Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	No

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	Closed Circuit TV & Door Alarms
Computer Energy Management	Yes
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Asphalt

DENVER-BOULDER / BOULDER BUS FACILITY
RTD
BOULDER, COLORADO

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	285
Offices	1591
Conference Room	267
Other	1143
** TOTAL **	3286

TRANSPORTATION SPACE

	(sq. ft.)
Offices	240
Locker Room	1050
Train Room	854
Training Room	500
Lunch Room	268
Radio,Dispatch	395
Fare Box Room	0
Storage	0
** TOTAL **	3788

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	8
Indoor Parking Spaces	96
Number of Axle Lifts	6
Number of Wheel Lifts	1
Number of Pits	0

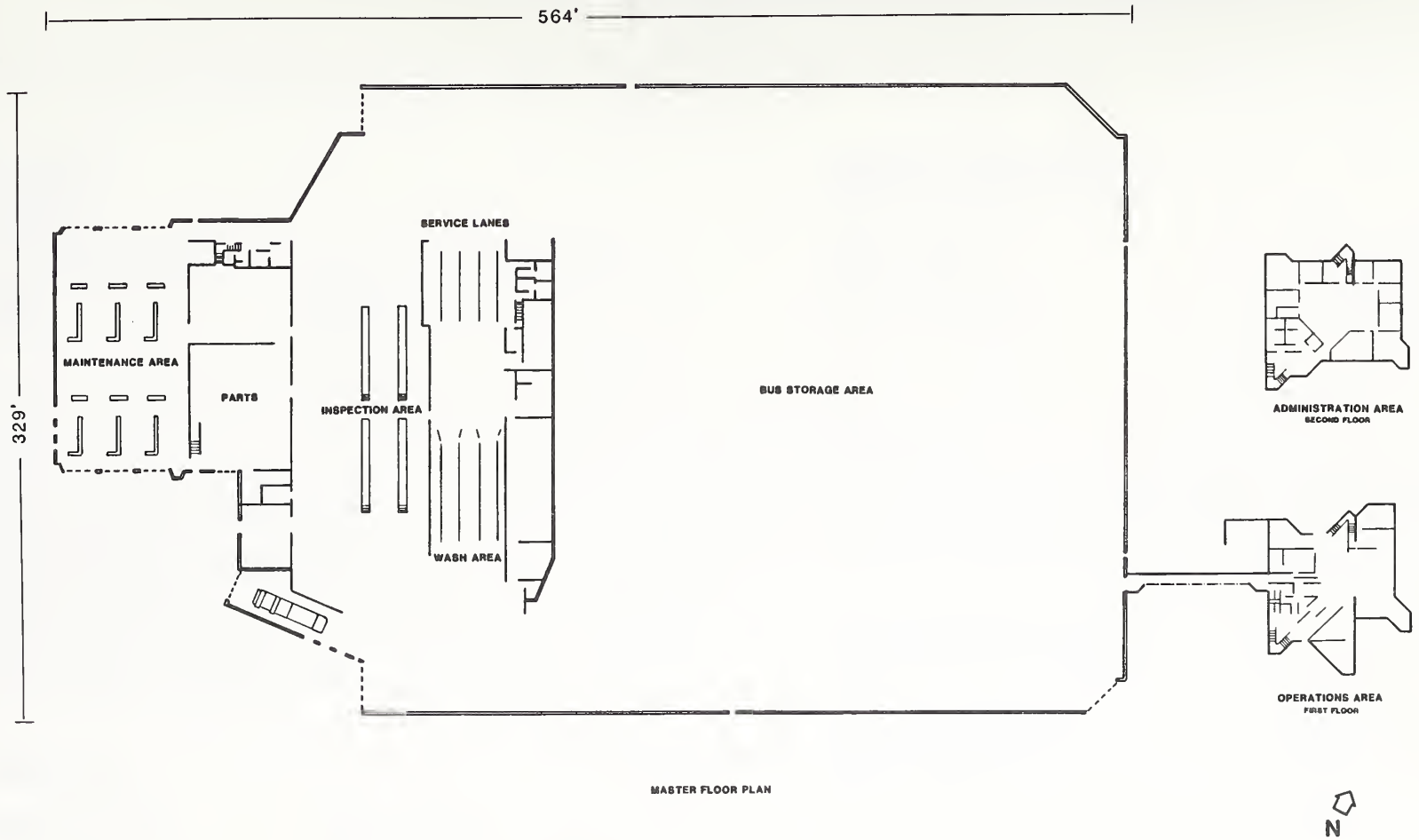
	(sq. ft.)
Offices	248
Locker Room	396
Body Repair	0
Dynamometer Bay	0
General Repair	3480
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	5724
Storage	96
Lunch Room	0
Paint Booth	0
Steam Bay	1152
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	280
Brake Repair	0
** TOTAL **	35339

OPERATIONAL DATA

Capacity	120
Fleet	106
Peak Buses	77
Base Buses	39
Annual Bus Miles	3,082,983
Annual Bus Hours	220,213

PERSONNEL DATA

Total	155
Administrative	3
Transportation	108
Drivers	94
Other	14
Maintenance	44
Mechanics	27
Service	4
Other	13



MASTER FLOOR PLAN

DENVER-BOULDER / BOULDER BUS FACILITY
REGIONAL TRANSPORTATION DISTRICT

Architect: Nixon, Brown, Brokaw, Bowen/Stansberry/Parra
Architects and Planners -- A Joint Venture

Year Opened: 1979

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	Precast Concrete Panels
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	20'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	14'-0"
Ceiling Height, Main Parts Level	9'-0"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	4'-6"

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	NA
Bus Storage Area	High Pressure Sodium
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	Yes
Heat Source	Hot Water Boiler
Heat Source Fuel	Solar and Gas/Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Solar and Gas/Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	Door Alarms
Computer Energy Management	Yes
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Concrete and Asphalt

DENVER-LONGMONT / LONGMONT BUS FACILITY
RTD
LONGMONT, COLORADO

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	132
Offices	178
Conference Room	171
Other	1773
** TOTAL **	2254

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	752
Training Room	0
Lunch Room	0
Radio,Dispatch	144
Fare Box Room	0
Storage	0
** TOTAL **	896

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	2
Indoor Parking Spaces	16
Number of Axle Lifts	1
Number of Wheel Lifts	0
Number of Pits	0

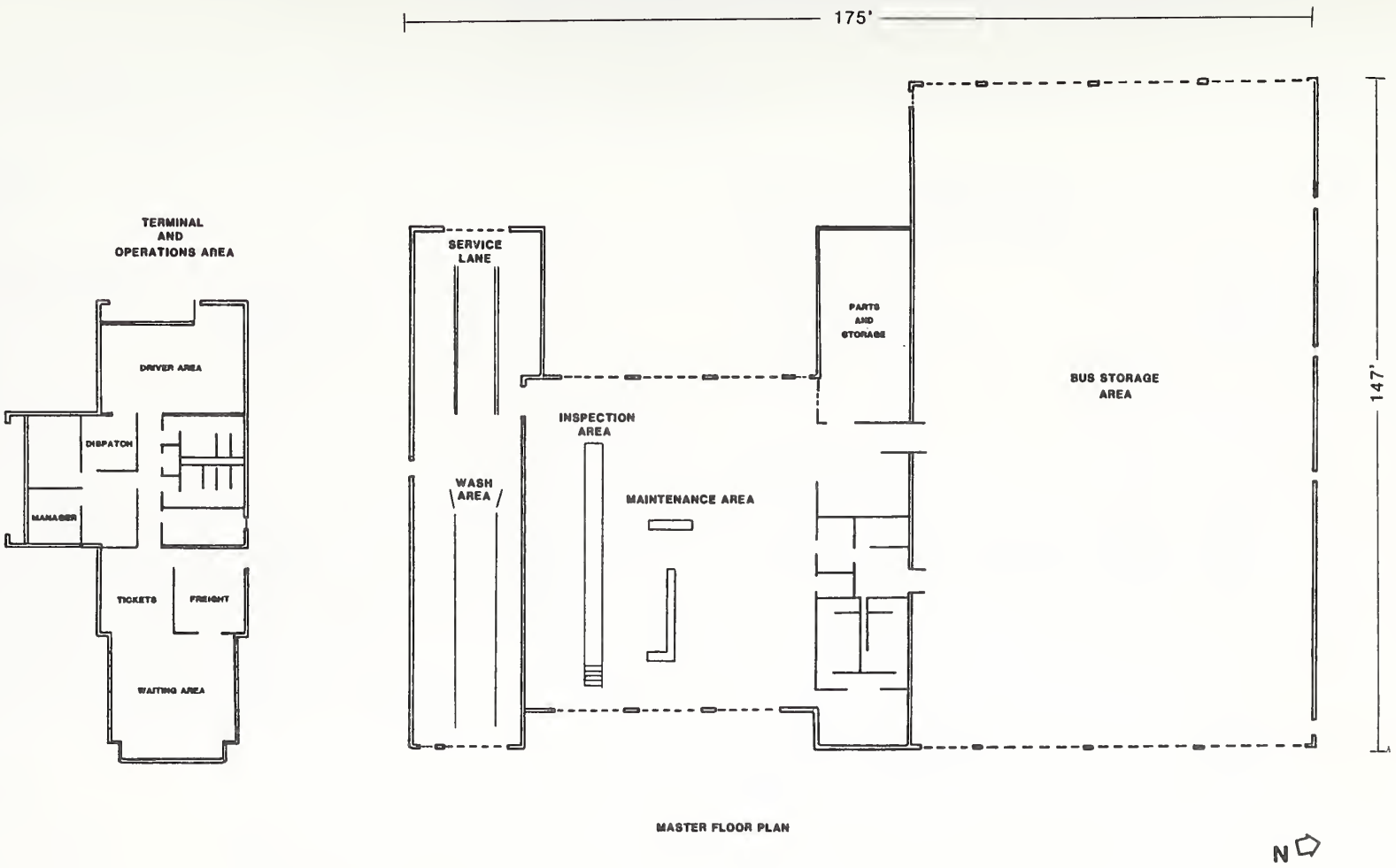
	(sq. ft.)
Offices	0
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	2862
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	841
Storage	0
Lunch Room	240
Paint Booth	0
Steam Bay	0
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	0
Brake Repair	0
** TOTAL **	8719

OPERATIONAL DATA

Capacity	16
Fleet	12
Peak Buses	10
Base Buses	8
Annual Bus Miles	349,016
Annual Bus Hours	24,929

PERSONNEL DATA

Total	58
Administrative	0
Transportation	40
Drivers	36
Other	4
Maintenance	18
Mechanics	10
Service	2
Other	6



MASTER FLOOR PLAN

DENVER-LONGMONT / LONGMONT BUS FACILITY
REGIONAL TRANSPORTATION DISTRICT

Architect: Community Architects, Inc.
Year Opened: 1979

BUILDING SHELL

Structural Framing	Prestressed Concrete
Exterior Walls	Masonry
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"
Ceiling Height Service Area	16'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0",14'-0"&22'-0"
Ceiling Height, Main Parts Level	10'-0"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	4'-6"

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	NA
Bus Storage Area	Fluorescent
Exterior Areas	Metal Halide

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Air Units
Heat Source Fuel	Gas
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	No
Security System	Door Alarms
Computer Energy Management	No
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Asphalt w/Concrete in High Traffic Areas

PHOENIX - NORTH / NORTH SATELLITE BUS MAINTENANCE FACILITY
CITY OF PHOENIX
PHOENIX, ARIZONA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	95
Conference Room	0
Other	282
** TOTAL **	377

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	1184
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	497
Fare Box Room	0
Storage	0
** TOTAL **	2540

MAINTENANCE SPACE

Number of Service Lanes	2
Number of Maintenance Bays	11
Indoor Parking Spaces	0
Number of Axle Lifts	8
Number of Wheel Lifts	3
Number of Pits	0

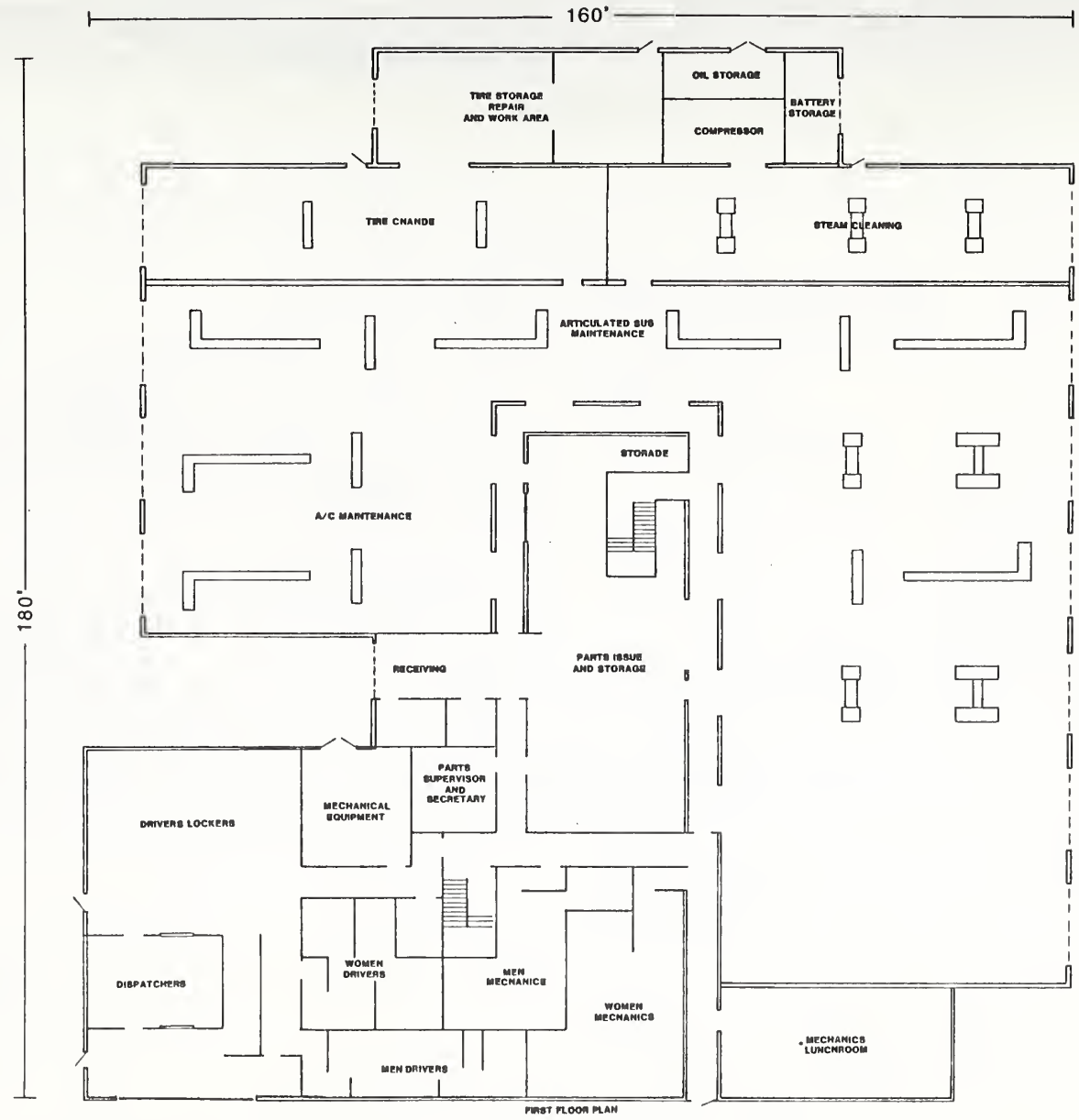
	(sq. ft.)
Offices	182
Locker Room	1250
Body Repair	0
Dynamometer Bay	0
General Repair	11540
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	1589
Storage	388
Lunch Room	760
Paint Booth	0
Steam Bay	1600
Overhaul	0
Fare Box Repair	0
Tire Bay	1580
Machine Shop	0
Battery Room	180
Brake Repair	0
** TOTAL **	28739

OPERATIONAL DATA

Capacity	200
Fleet	93
Peak Buses	77
Base Buses	61
Annual Bus Miles	1,937,504
Annual Bus Hours	140,056

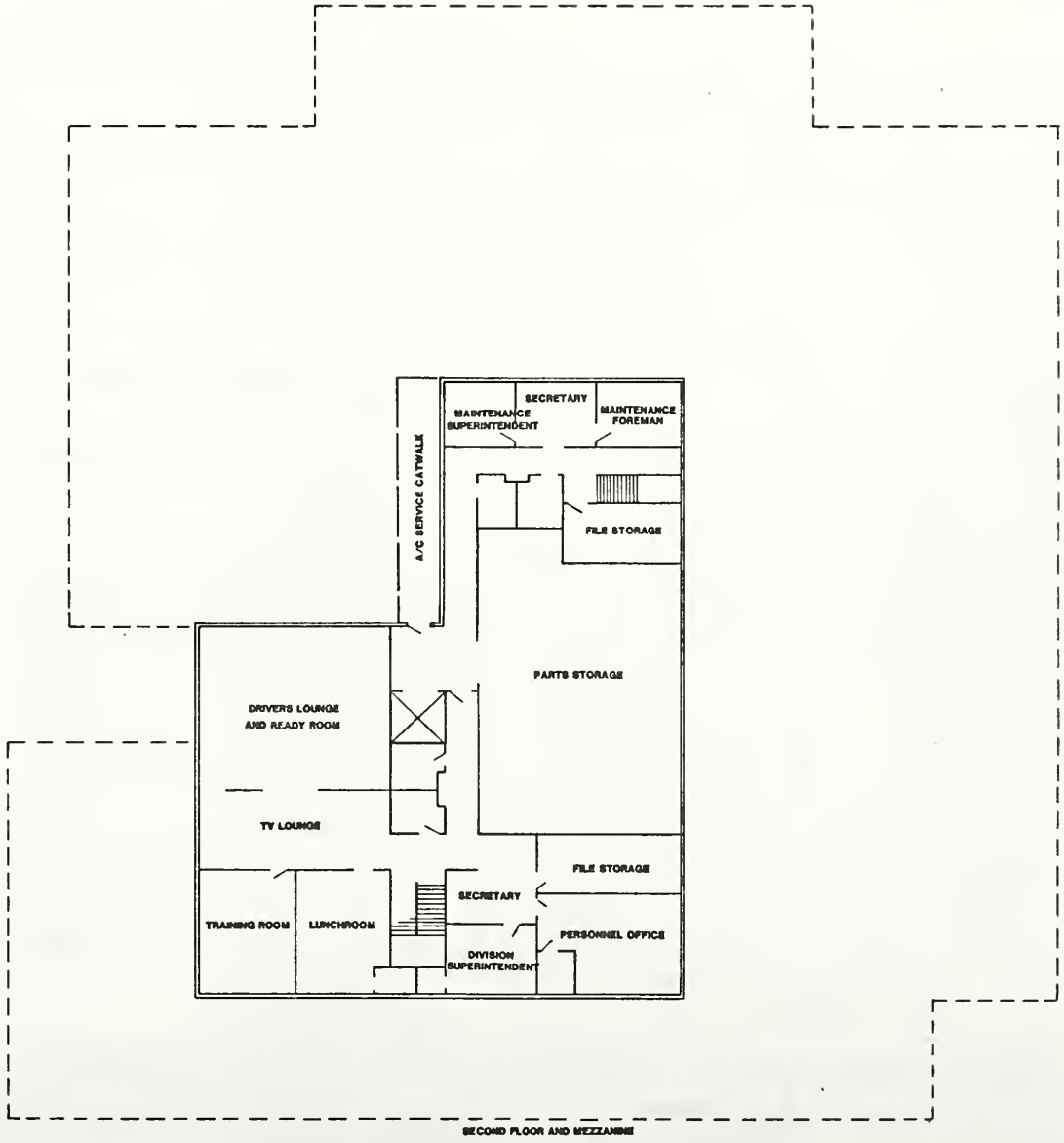
PERSONNEL DATA

Total	150
Administrative	3
Transportation	111
Drivers	105
Other	6
Maintenance	36
Mechanics	20
Service	15
Other	1



PHOENIX-NORTH / NORTH SATELLITE BUS MAINTENANCE FACILITY
CITY OF PHOENIX

Architect: Wadsworth, Jensen and Associates
Year Opened: 1981



PHOENIX-NORTH / NORTH SATELLITE BUS MAINTENANCE FACILITY
CITY OF PHOENIX

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	24'-0"
Ceiling Height Service Area	14'-0",18'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	14'-0"
Ceiling Height, Main Parts Level	12'-0"
Ceiling Height, Upper Parts Level	12'-0"
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	Metal Halide
Low Bay Area	NA
Bus Storage Area	NA
Exterior Areas	Metal Halide

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Water Boiler
Heat Source Fuel	Gas
Areas Cooled	Office Areas, Shops by Evaporative Cooling

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	Yes
Security System	Closed Circuit TV,Guards,Alarm in Vault
Computer Energy Management	Yes
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt, Concrete in Fueling Area

PHOENIX - SOUTH / TRANSIT HEAVY MAINTENANCE FACILITY
CITY OF PHOENIX
PHOENIX, ARIZONA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	0

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	31
Indoor Parking Spaces	0
Number of Axle Lifts	9
Number of Wheel Lifts	8
Number of Pits	2

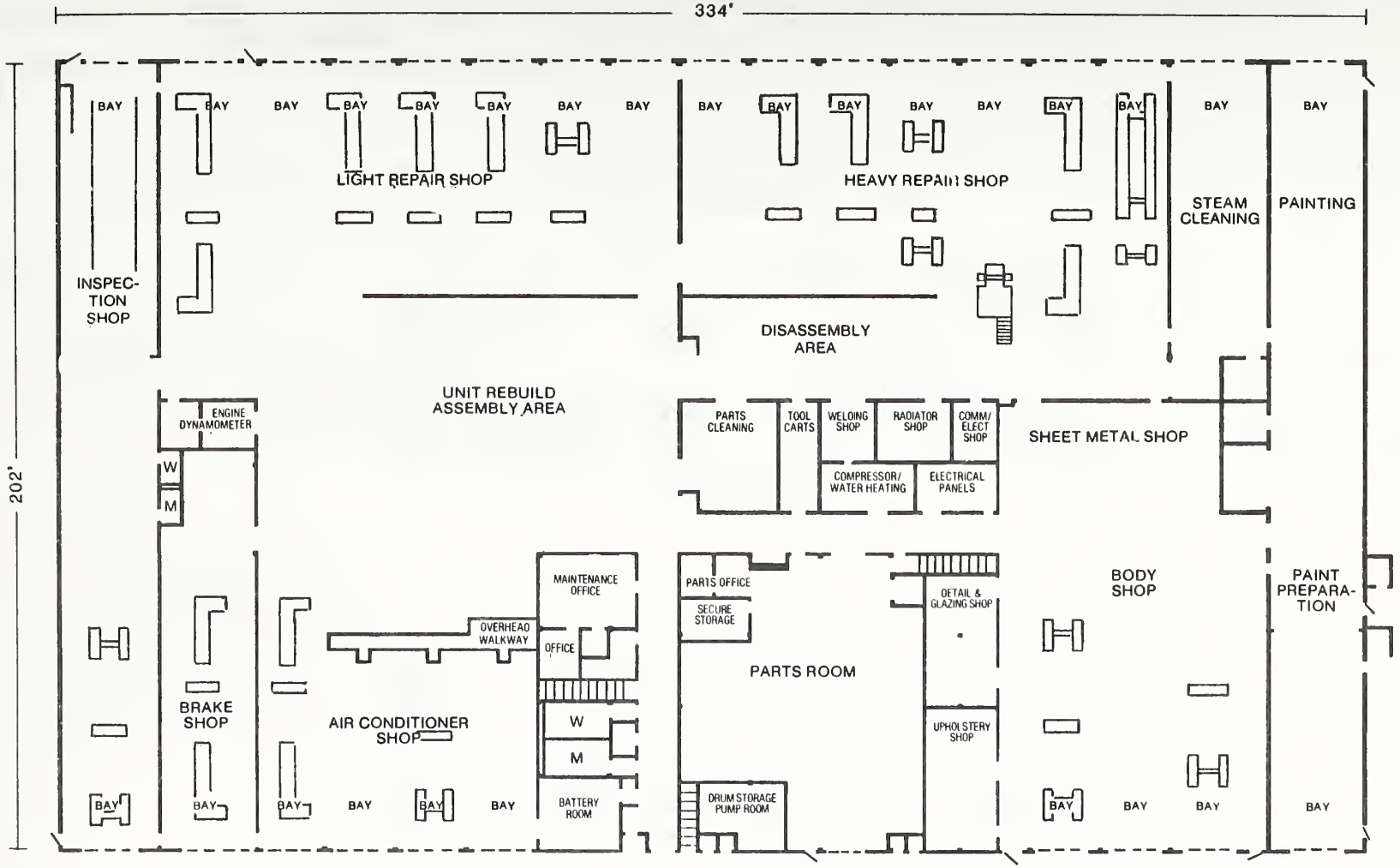
	(sq. ft.)
Offices	1035
Locker Room	1696
Body Repair	0
Dynamometer Bay	0
General Repair	30498
Parts Cleaning	700
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	9788
Storage	3601
Lunch Room	702
Paint Booth	5153
Steam Bay	2150
Overhaul	0
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	380
Brake Repair	360
** TOTAL **	71533

OPERATIONAL DATA

Capacity	400
Fleet	154
Peak Buses	136
Base Buses	75
Annual Bus Miles	3,161,190
Annual Bus Hours	228,512

PERSONNEL DATA

Total	316
Administrative	15
Transportation	211
Drivers	191
Other	20
Maintenance	90
Mechanics	50
Service	27
Other	13

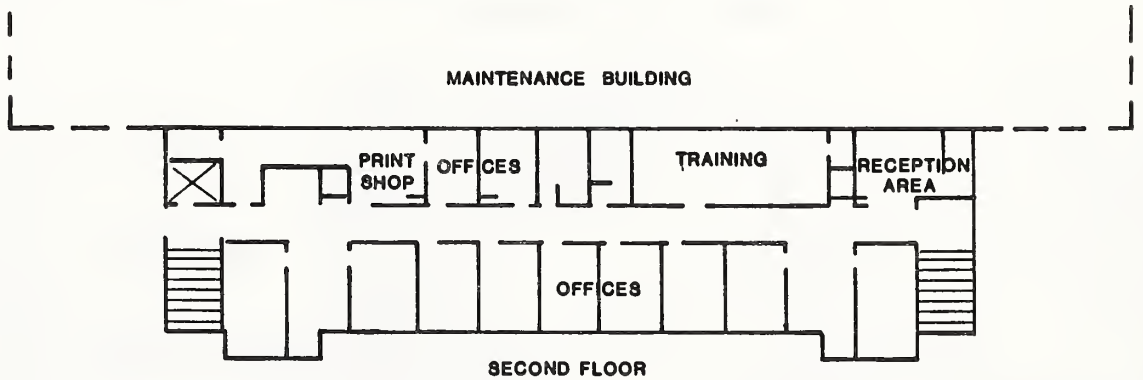


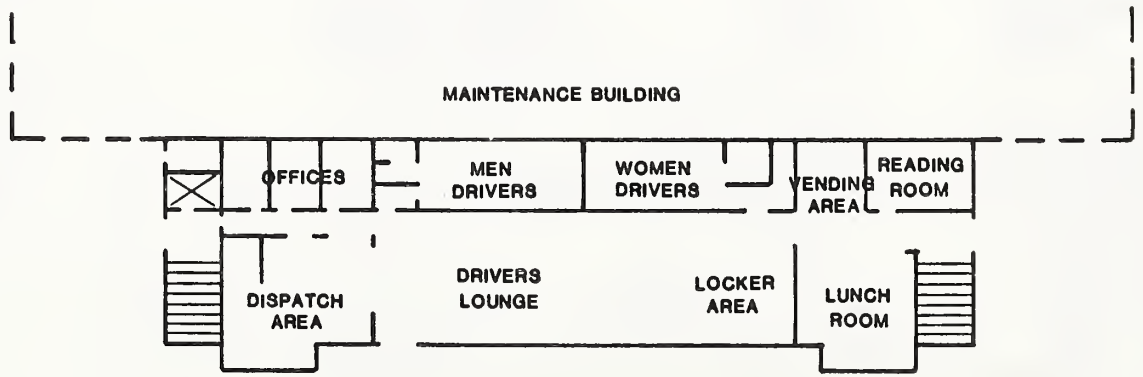
MASTER FLOOR PLAN

PHOENIX-SOUTH / TRANSIT HEAVY MAINTENANCE FACILITY
CITY OF PHOENIX

Architect: Benham, Blair, Ditzler & Elling
Architects & Engineers
De Leuw, Cather & Company

Year Opened: 1982





OPERATIONS BUILDING / FIRST FLOOR

PHOENIX-SOUTH / TRANSIT HEAVY MAINTENANCE FACILITY
CITY OF PHOENIX

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Masonry
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	24'-0"
Ceiling Height Service Area	14'-0",18'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	14'-0"
Ceiling Height, Main Parts Level	12'-0"
Ceiling Height, Upper Parts Level	12'-0"
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	5'-0"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	High Pressure Sodium
Bus Storage Area	NA
Exterior Areas	Metal Halide

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot. Air in Shops, Heat Pump in Offices
Heat Source Fuel	Gas
Areas Cooled	Office areas by Heat Pumps Shops by Evaporating Cooling

PLUMBING

Heat Source Fuel for Hot Water	Gas
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Water Wash
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	Yes
Security System	System Closed Circuit TV, Guards, Alarm in Vault
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt Concrete in Fueling Area

SEATTLE / CENTRAL OPERATING BASE AND MAINTENANCE BUILDING
MUNICIPALITY OF METROPOLITAN SEATTLE
SEATTLE, WASHINGTON

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	0

MAINTENANCE SPACE

Number of Service Lanes	0
Number of Maintenance Bays	17
Indoor Parking Spaces	0
Number of Axle Lifts	7
Number of Wheel Lifts	5
Number of Pits	0

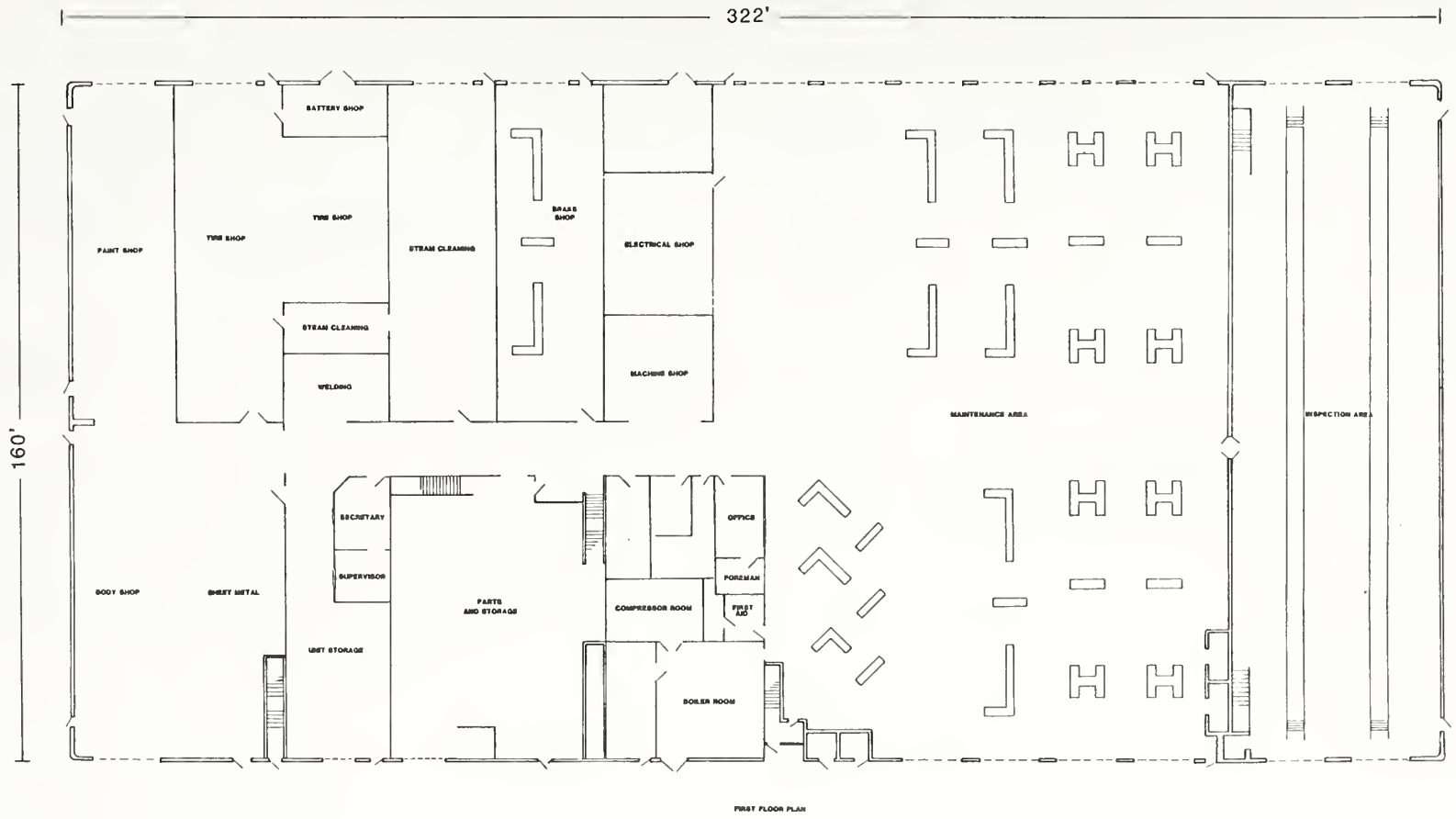
	(sq. ft.)
Offices	602
Locker Room	1608
Body Repair	0
Dynamometer Bay	0
General Repair	19280
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	3705
Storage	3079
Lunch Room	655
Paint Booth	2000
Steam Bay	2252
Overhaul	1268
Fare Box Repair	0
Tire Bay	0
Machine Shop	0
Battery Room	275
Brake Repair	2000
** TOTAL **	54776

OPERATIONAL DATA

Capacity	400
Fleet	312
Peak Buses	
Base Buses	
Annual Bus Miles	
Annual Bus Hours	

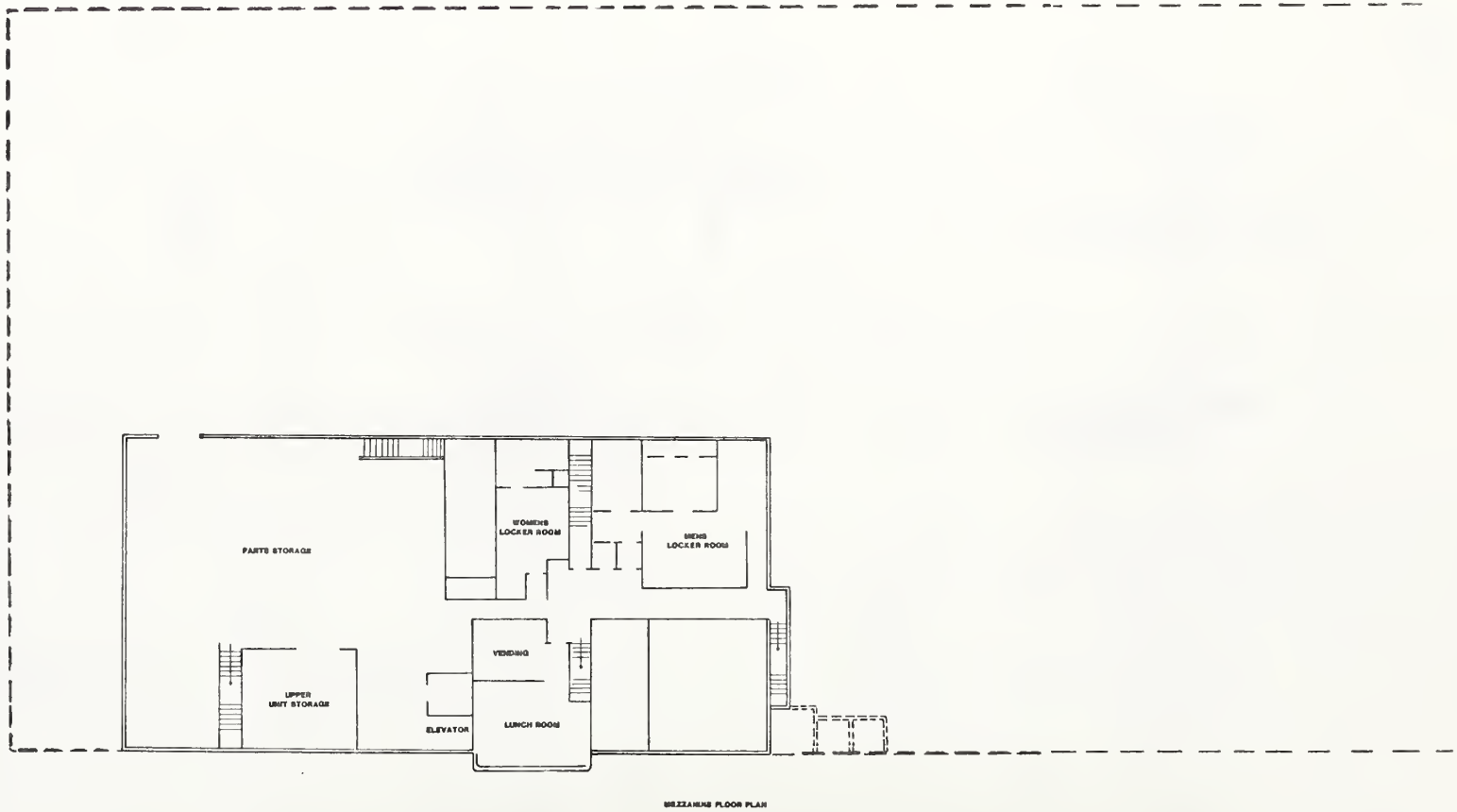
PERSONNEL DATA

Total	106
Administrative	6
Transportation	0
Drivers	0
Other	0
Maintenance	100
Mechanics	48
Service	41
Other	11



SEATTLE / CENTRAL OPERATING BASE AND MAINTENANCE BUILDING
MUNICIPALITY OF METROPOLITAN SEATTLE

Architect: De Leuw, Cather & Company
Year Opened: 1980



MEZZANINE FLOOR PLAN

SEATTLE / CENTRAL OPERATING BASE AND MAINTENANCE BUILDING
MUNICIPALITY OF METROPOLITAN SEATTLE

BUILDING SHELL

Structural Framing	Cast-in-Place Concrete
Exterior Walls	Cast-in-Place Concrete
Roof	Prestressed Concrete
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	20'-0"-22'-0"
Ceiling Height Service Area	20'-0"
Bus Garage Door Opening Height	14'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	11'-0"
Ceiling Height, Upper Parts Level	9'-0"
Door Height, Forklift Access	NA
Inspection and Running Repair Pit Depth	5'-6"

LIGHTING

High Bay Area	Fluorescent
Low Bay Area	Fluorescent
Bus Storage Area	NA
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Steam Boiler
Heat Source Fuel	Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	Yes
Cleaning Method	Dry Filter
Make Up Air Heated	Yes
Heat Recovery	No

OTHER

Emergency Power Source	No
Security System	None
Computer Energy Management	No
Air Curtains at Garage Doors	No
Type of Exterior Pavement	Asphalt with Concrete Aprons

ST. PAUL / BUS OVERHAUL FACILITY
ST. PAUL, MINNESOTA

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	0
Offices	0
Conference Room	0
Other	0
** TOTAL **	0

TRANSPORTATION SPACE

	(sq. ft.)
Offices	0
Locker Room	0
Train Room	0
Training Room	0
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	0

MAINTENANCE SPACE

Number of Service Lanes	0
Number of Maintenance Bays	45
Indoor Parking Spaces	0
Number of Axle Lifts	31
Number of Wheel Lifts	0
Number of Pits	4

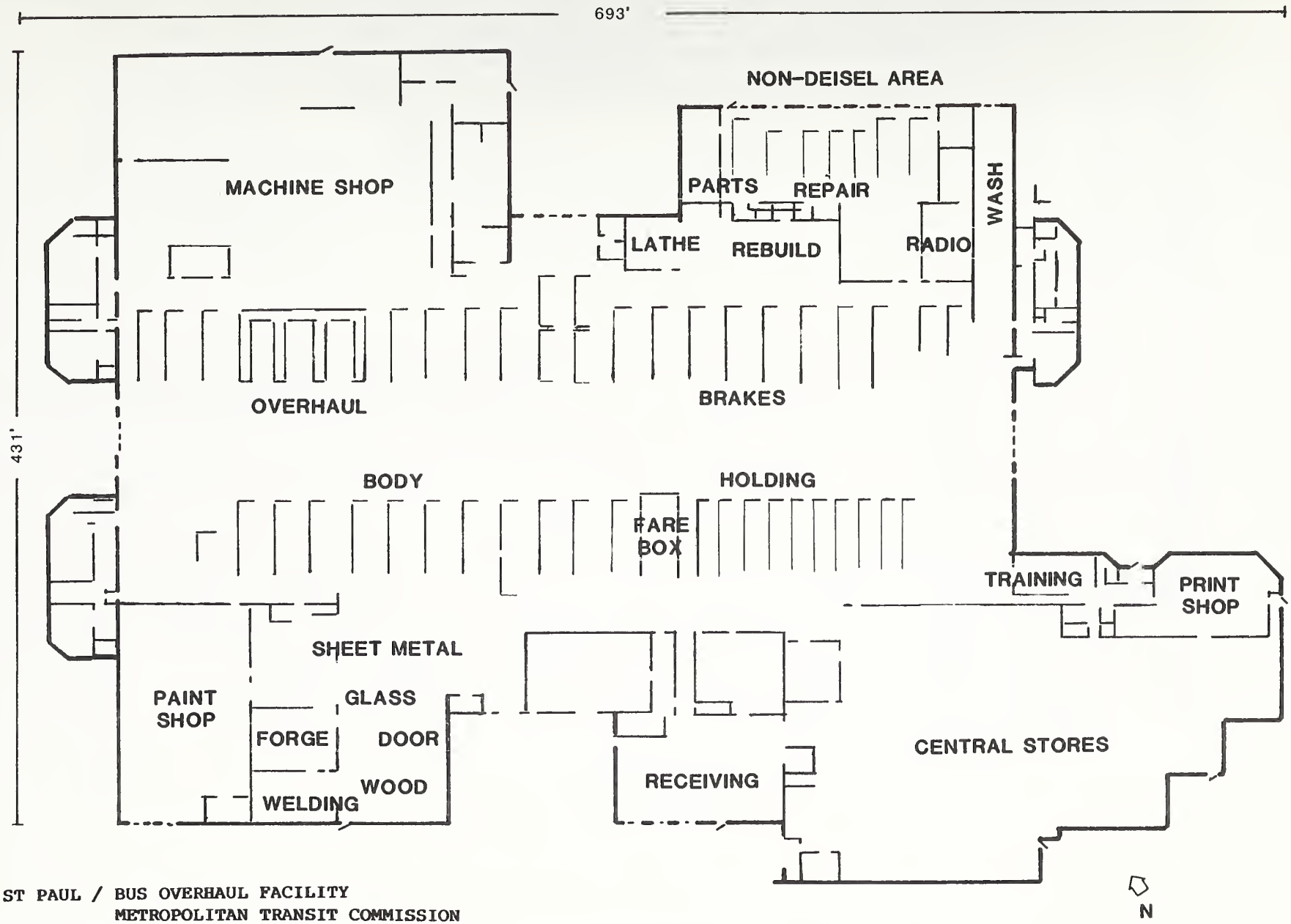
	(sq. ft.)
Offices	4000
Locker Room	2448
Body Repair	48600
Dynamometer Bay	0
General Repair	4198
Parts Cleaning	2246
Injector Room	0
Brake Bay & Repair	20600
Wheel Alignment	0
Parts Room	26685
Storage	3342
Lunch Room	960
Paint Booth	5184
Steam Bay	2880
Overhaul & Machine Shop	46600
Fare Box Repair	400
Tire Bay	500
Battery Room	144
** TOTAL **	168787

OPERATIONAL DATA

Capacity	-
Fleet	1066
Peak Buses	-
Base Buses	-
Annual Bus Miles	N/A
Annual Bus Hours	N/A

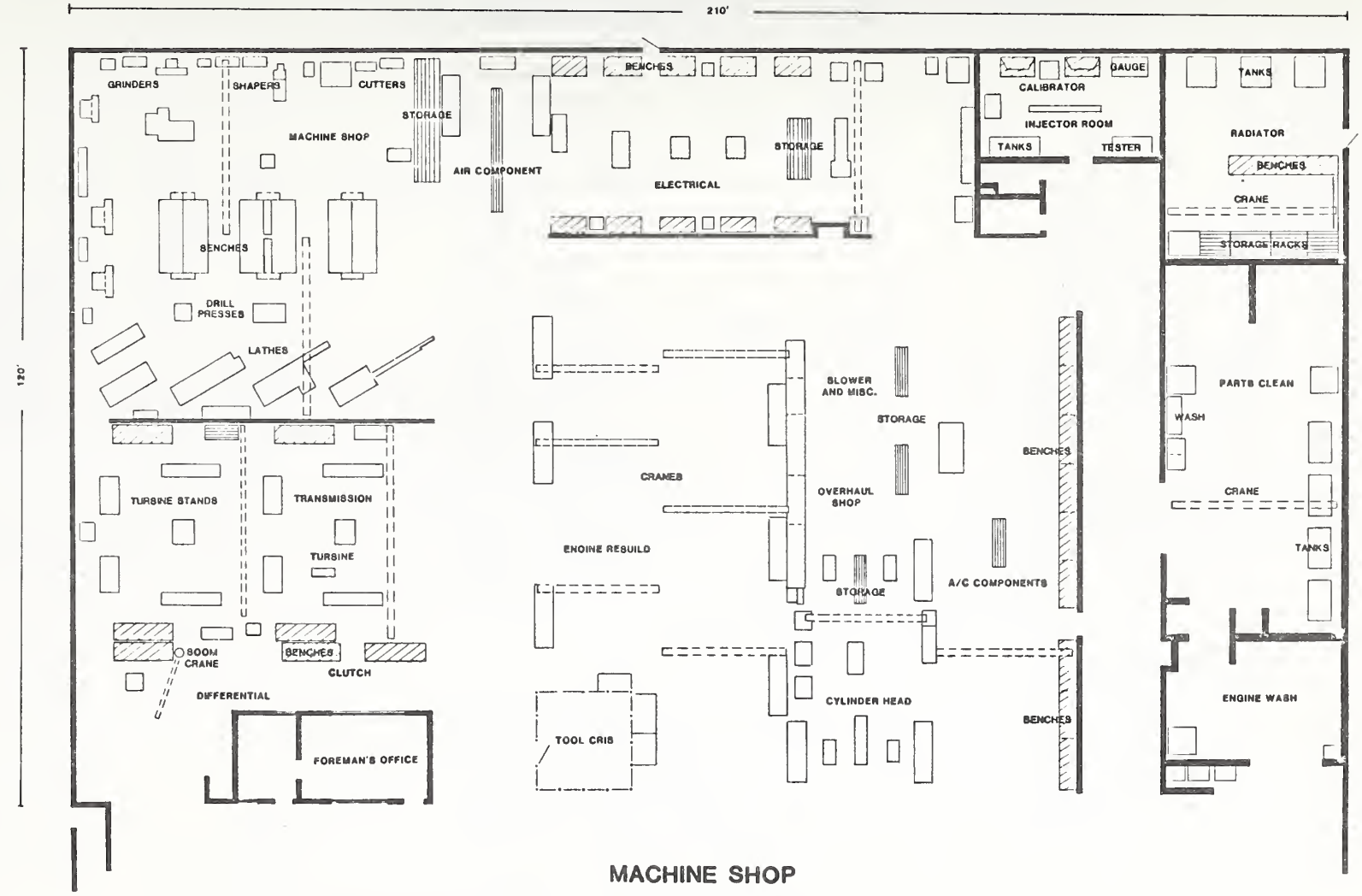
PERSONNEL DATA

Total	122
Administrative	25
Transportation	0
Drivers	0
Other	0
Maintenance	97
Mechanics	97
Service	0
Other	0



ST PAUL / BUS OVERHAUL FACILITY
METROPOLITAN TRANSIT COMMISSION

Architect: Ellerbe Industrial Engineers & Architects
Year Opened: 1981



MACHINE SHOP
FLOOR PLAN

ST PAUL / BUS OVERHAUL FACILITY
METROPOLITAN TRANSIT COMMISSION

WASHINGTON, D.C. / NICHOLSON LANE METRO BUS GARAGE FACILITY
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
MONTGOMERY COUNTY, MARYLAND

ADMINISTRATIVE SPACE

	(sq. ft.)
Manager's Office	320
Offices	320
Conference Room	0
Other	0
** TOTAL **	640

TRANSPORTATION SPACE

	(sq. ft.)
Offices	1440
Locker Room	0
Train Room	2240
Training Room	432
Lunch Room	0
Radio,Dispatch	0
Fare Box Room	0
Storage	0
** TOTAL **	7056

MAINTENANCE SPACE

Number of Service Lanes	3
Number of Maintenance Bays	16
Indoor Parking Spaces	0
Number of Axle Lifts	14
Number of Wheel Lifts	0
Number of Pits	1

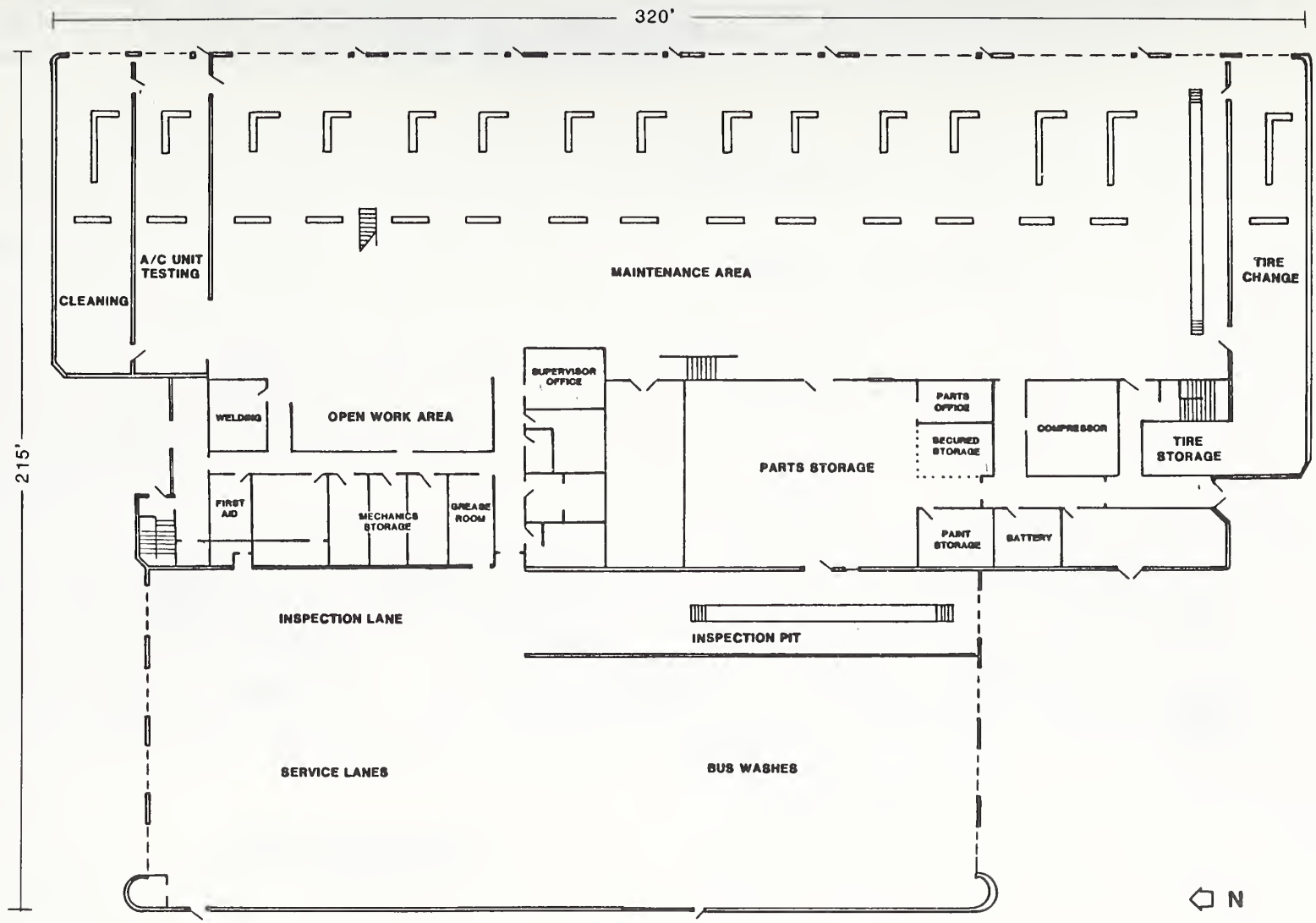
	(sq. ft.)
Offices	720
Locker Room	0
Body Repair	0
Dynamometer Bay	0
General Repair	19600
Parts Cleaning	0
Injector Room	0
Brake Bay	0
Wheel Alignment	0
Parts Room	3250
Storage	525
Lunch Room	912
Paint Booth	0
Steam Bay	1476
Overhaul	0
Fare Box Repair	0
Tire Bay	1908
Machine Shop	0
Battery Room	225
Brake Repair	0
** TOTAL **	54580

OPERATIONAL DATA

Capacity	225
Fleet	147
Peak Buses	125
Base Buses	50
Annual Bus Miles	4,836,072
Annual Bus Hours	403,006

PERSONNEL DATA

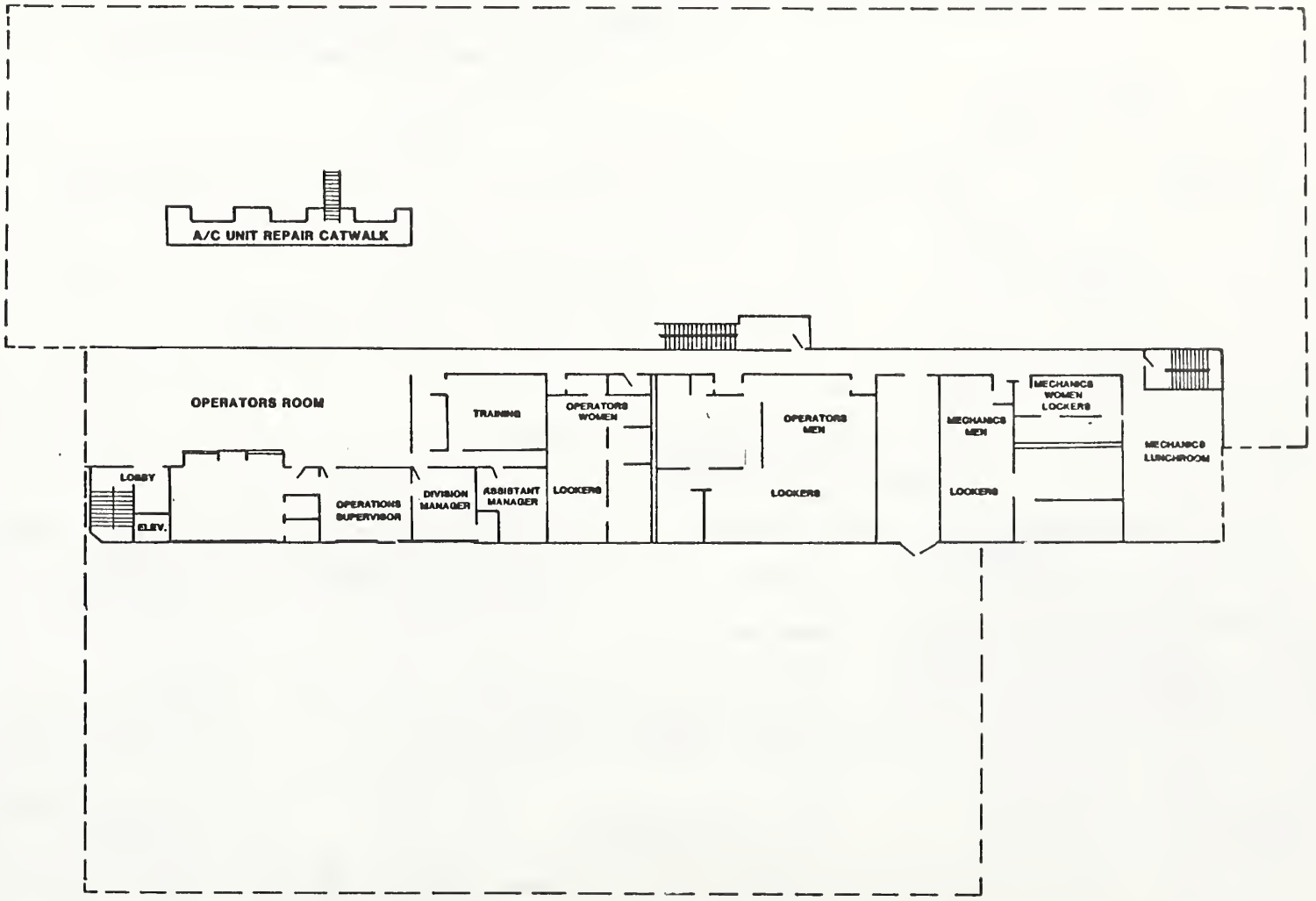
Total	248
Administrative	2
Transportation	205
Drivers	200
Other	5
Maintenance	41
Mechanics	20
Service	12
Other	9



MASTER FLOOR PLAN

WASHINGTON, D.C. / NICHOLSON LANE METRO BUS GARAGE FACILITY
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

Architect: Mariani & Associates
Year Opened: 1982



MEZZANINE FLOOR PLAN

WASHINGTON, D.C. / NICHOLSON LANE METRO BUS GARAGE FACILITY
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

* U.S. GOVERNMENT PRINTING OFFICE: 1988-516-018:80281

WASHINGTON, DC / CONTINUED

BUILDING SHELL

Structural Framing	Structural Steel
Exterior Walls	Insulated Metal Panels
Roof	Metal Deck
Floors	Concrete

CLEARANCES

Ceiling Height in Areas with Vehicle Lifts	22'-0"
Ceiling Height Service Area	18'-0"
Bus Garage Door Opening Height	13'-0",16'-0"
Bus Garage Door Opening Width	12'-0"
Ceiling Height, Main Parts Level	13'-0"
Ceiling Height, Upper Parts Level	NA
Door Height, Forklift Access	8'-0"
Inspection and Running Repair Pit Depth	5'-6"

LIGHTING

High Bay Area	High Pressure Sodium
Low Bay Area	Nigh Pressure Sodium
Bus Storage Area	NA
Exterior Areas	High Pressure Sodium

HEATING, VENTILATING AND AIR CONDITIONING

Solar Assist	No
Heat Source	Hot Air Heater
Heat Source Fuel	Oil
Areas Cooled	Office Areas

PLUMBING

Heat Source Fuel for Hot Water	Oil
Heat Recovery for Waste Water	No
Oil/Water Separator	Yes

PAINTING FACILITIES

Exhaust Air Cleaned	NA
Cleaning Method	NA
Make Up Air Heated	NA
Heat Recovery	NA

OTHER

Emergency Power Source	Yes
Security System	Closed Circuit TV & Guards
Computer Energy Management	Yes
Air Curtains at Garage Doors	Yes
Type of Exterior Pavement	Concrete

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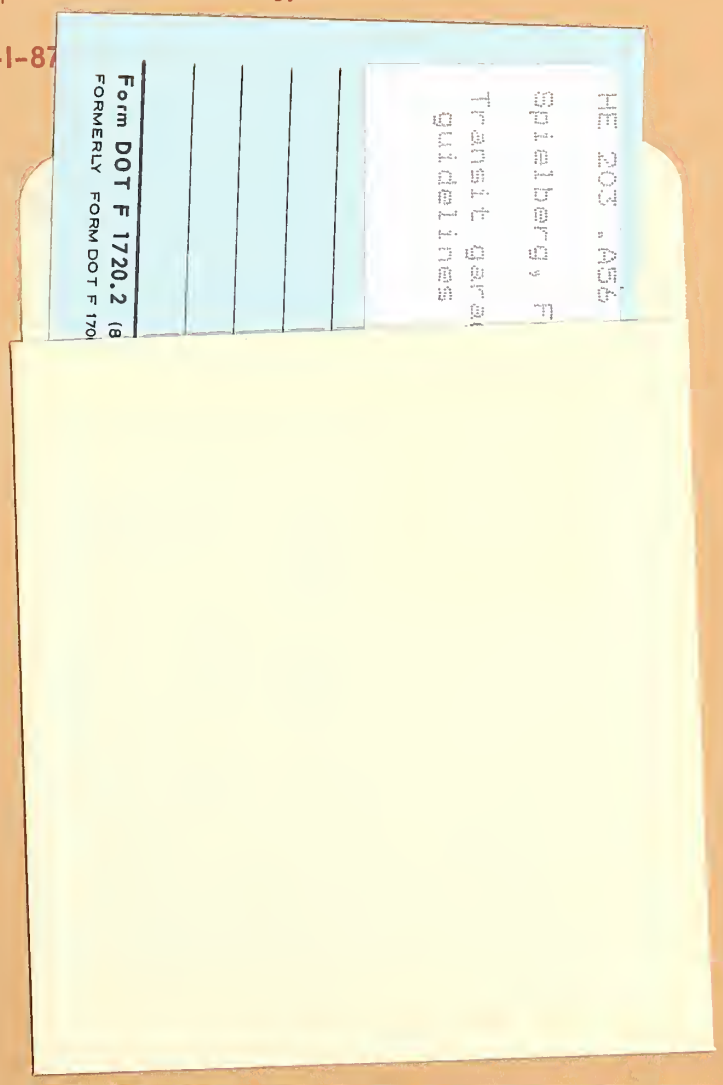

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PROGRAMS OF THE U.S. DEPARTMENT OF TRANSPORTATION